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POWER

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Volume 69 New York, March 5, 1929 *Number 10*

Freedom

WE HAVE just finished celebrating the anniversary of the birth of Abraham Lincoln, the Great Emancipator.

It is not to be believed that property in human beings would have long survived the growing culture of the race and the replacement of human by machine labor.

What a pity that it could not have died a natural death instead of instigating the fratricidal tragedy the wounds of which will take so long to heal and the scars of which will be ineradicable.

The slave is now free to go whither he listeth and to live his life his own way, but he is still, like the rest of us, a slave to his necessities and to his environment.

The declaration that "All men are born free and equal" is sententious but untrue.

Few indeed are free to do every moment just what their interest urges and their inclination dictates.

And as for equality, we have them all the way from Bacon, Newton, Watt and Edison down.

In industry and in affairs some are qualified to lead and direct and have sufficient self-assertion to take the command.

In the struggle for existence and progress the majority must be privates, content with a chance to contribute that for which they are best fitted to the common cause and to receive a proportionate emolument.

Real freedom lies in the right to think and to express one's thoughts freely. Conditions are largely the result of a state of mind, and in the face of an intelligent public opinion made fearlessly manifest, human relations would not go far awry. Milton says: "Give me the liberty to know, to utter, and to argue freely, according to my conscience, above all other liberties."

F. R. Low

POWER *Stands for . . .*

1. **Making Power When It Should Be Made**
2. **Buying Power When It Should Be Bought**
3. **Cheaper Power Through Modern Equipment**
4. **Easier Financing of Equipment Purchases**
5. **Better Use of Byproduct Heat and Power**
6. **Operating Methods That Save Money**
7. **Less Waste in Transmission and Application**

Modern Equipment Can Do the Job

WHEN Indians roamed the great expanse now known as the United States, three and one-half trillion tons of solid fuel lay beneath the soil. Today, after several centuries of American civilization, more than ninety-nine per cent of this original tonnage remains untouched. But this statement, unexplained, gives too rosy a picture of our present fuel resources. This apparently minute depletion represents about twenty-three per cent of our total anthracite and nearly two per cent of our bituminous coal (a much larger percentage of the *best* bituminous coal).

So the day when utilization of low-grade fuels will be a national necessity is not so far away as might appear. Far more urgent, however, is the present call to burn lignites and other low-grade fuels effectively in districts where such fuels are most available, thus avoiding high haulage costs.

A plant that obtains seventy-one per cent boiler and furnace efficiency when burning a six thousand B.t.u. lignite with forty per cent moisture content may be more to be praised than another attaining eighty per cent efficiency on Pocahontas. The story of the Washburn Station, told in this number, shows how modern stokers, air heaters and furnaces can handle low-grade fuels with ease and efficiency.

Aviation and the Power Field

ALTHOUGH the power engineer may have no direct connection with the aviation industry, there are certain aspects of its swift development that touch his interests deeply. In the more restricted view the increased use of air transportation will provide enlarged outlets for power-plant products—steam, fluid pressure and electric current. And, viewed broadly, an airplane is itself a power plant of specialized design. Its technology is a matter of more than passing interest to the power engineer, particularly to those who are concerned with oil engines.

Airplane production grows enormously. In 1927 the value of products made was $9,000,000. In 1928 the figure was $20,000,000. What 1929 will show cannot be foretold, but a proportionate increase can be confidently looked for.

This growing manufacturing industry is a user of power-plant products. Machining, pressing, heat treating and process heating are but a few of its most important power consuming operations. Its rate of growth rivals that shown in early days by the automotive industry. Aviation manufacture promises soon to take a place beside motor car making as a great power consuming industry.

In addition, the wide adoption of the airplane as a carrier means increased use of power in other ways. Lighting for flying fields and hangars, power for signal and control systems, and the needs of repair and service stations are but a few of the ways in which this new industry will call for the services of the power engineer.

So it may be said that, just as no great industry can grow without affecting the growth of power utilization and the fortunes of power engineers, air transportation development is of primary importance to the power field. *Power* therefore feels sure that its readers will profit from the fact that the McGraw-Hill Publishing Company has purchased the magazine *Aviation* and that henceforth the two journals will co-operate closely in advancing the mutual interests of their respective fields.

Fuel Reactivity— What It Means

OPERATORS of blast furnaces have long recognized the fact that coke varies in utility with its reactivity, which is one of several important governing properties of fuels. Power engineers do not seem, on the other hand, to have given this quality of reactivity, which concerns ease and speed of burning, the attention it deserves.

With solid fuels carbon is the principal constituent. It is characterized by the fact that its less dense forms react with gases, in combustion, far more rapidly than do the denser forms. For instance, charcoal and char from the carbonization of lignite and soft coals react with great rapidity, while ordinary (high-temperature) coke and anthracite coals are relatively slow to ignite and burn.

Assuming a given grate size and boiler surface, the steaming capacity of a boiler will depend upon its ability to absorb heat and the amount of heat that can be released on the grates by burning of fuel. Because this latter figure is a function of the reactivity of the fuel, it becomes worthy of attention.

Balancing the cost of one fuel along with the output it gives per unit of boiler development against similar figures for another, it may well be that a highly reactive fuel, though of greater first cost, will give cheaper steam than a low-priced fuel. Because of this, it may be found good economy, in the future when supplies are available, to burn processed fuels such as low-temperature coke, which is extremely reactive, even though they cost more.

The New Era of High Steam Pressures

WHILE the occasional use of high steam pressures, one thousand pounds and over, is by no means new, it seems likely that the year 1929 will mark their general commercial acceptance.

Results announced by trustworthy pioneers here and abroad have largely broken down the scepticism that was almost universal a few years back. Several central stations are operating regularly at twelve hundred pounds. Other high-pressure installations are under construction in central stations and still others are being planned. Definite announcement of several projected high-pressure industrial plants is reinforced by persistent rumors to the effect that certain leading manufacturers, mostly in the process industries, are giving serious thought to the subject.

The time lag in America from executive attention to accomplishment is growing less and less as industry gets on a more scientific basis. It will be indeed surprising if 1929 does not bring forth many new announcements of high-pressure projects.

Insulation Tests a Form of Insurance

INSULATION is of prime importance in electric machine design and operation. It must withstand abnormal voltages encountered in operation; otherwise, a breakdown to ground or between conductors will result. How to determine when insulation possesses these qualities is not always easy. Insulating materials have unstable characteristics. When dry, resistance and dielectric strength may be high, but when exposed to a damp atmosphere, these qualities may be materially decreased. Dust and dirt on insulation also impair its ability to withstand voltage stresses.

For new machines insulation standards have been established. These, however, apply to new insulation after it has been thoroughly dried out. After it has been in service, the conditions may be quite different. Mechanical and temperature stresses may cause minute cracks in the insulation and dirt and oil may be carried into contact with all parts of the winding surfaces. When this has occurred, even after the windings have been cleaned and dried out, the insulation is not restored to its original condition. For this reason the windings should not be subjected to the standard high-voltage test.

How high a test voltage to apply to a used machine is a question that has been much discussed. Opinions vary widely. Some are opposed to a test voltage above twenty-five per cent of normal. Others advocate a much higher test. Agreement is lacking as to how long the test voltage should be applied. This is as important as the value of the voltage. A potential that might not injure insulation if applied for a second may cause serious damage if left on for a minute.

The application of test voltages to used machines may be considered as an insurance against unexpected failure in service. This being the case, the next question is: How much insurance is required? The system operating requirements will determine this. If a machine can be tripped off the load without causing serious difficulties, the same degree of insurance against failure may not be required as when the breakdown would lead to serious consequences. In the former case, periodic cleaning of the windings, followed by insulation-resistance tests, may suffice; for the latter case a test voltage twenty-five per cent less than the factory value might be deemed necessary. If operators wish the latter, they must expect to pay for it in winding failures under test—windings that would otherwise have given many years of useful life.

Industry Grows at a Steady Rate

THERE is an old saying, trite through much use, that tells of the man who could not see the forest for the trees. Contrary to general experience with such catch-phrases, this one aptly fits many situations. One such is the general condition of industry. Each sees clearly but a small portion of this great field, that with which his daily work is concerned. Because textile manufacture or leather tanning or some other branch in which the individual engineer is engaged has been highly prosperous or greatly depressed for a time, he tends to think that all industry has experienced the same vicissitudes.

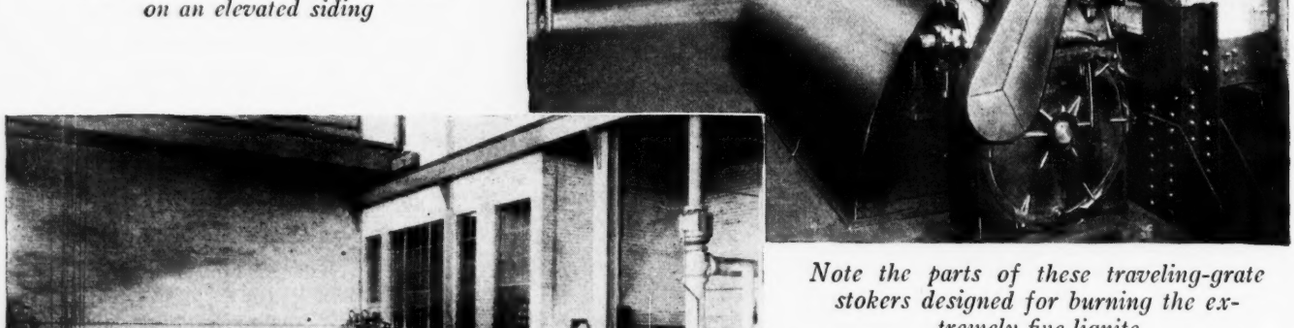
This is, however, far from the case. When one industry is up, another is likely to be down. Carried through all the branches of industry, the effect on the general trend is to flatten out the peaks and valleys and give an almost smooth curve with a slight upward tendency.

This was well brought out by Dr. Carl Snyder, of the Federal Reserve Bank, who, speaking recently before the American Institute of Mining and Metallurgical Engineers, discussed the "Long Time Growth of Industry." According to figures given in this talk production in all industries, including agriculture, increases at an almost steady rate of three and one-half per cent per annum. Manufacturing growth is almost regular, at four per cent yearly, while bank debits have grown at four per cent each year for the last forty years, with but slight variations.

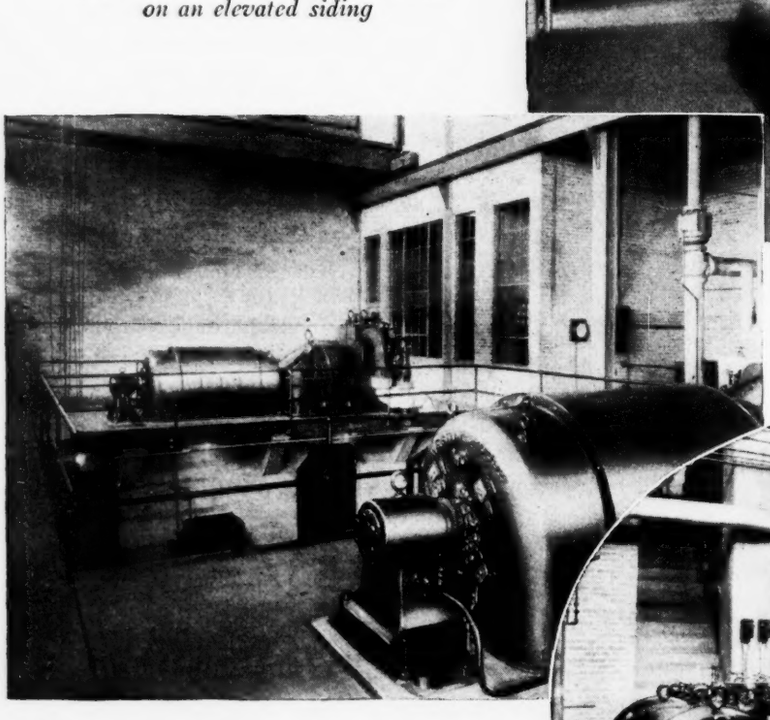
Apparently, this rate of growth is so well established that it can safely be used as a means for estimating the future. It is also said that profits made by industry are, on the whole, steady at a fixed percentage of the value of production.

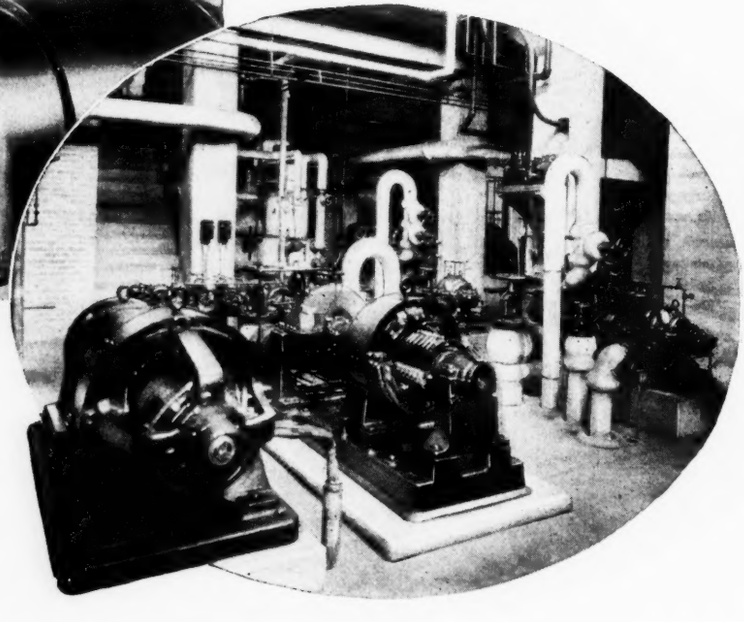
If these are facts, and they seem to be with forty years of experience as their basis, then industry can proceed with much greater confidence than has heretofore been justified. In power development, for instance, if the relation between industry growth and power utilization increase is established, it can be applied to this four per cent figure and expansions planned then for the future with less danger of over- or under-building than formerly. Engineers will await with interest studies, by Doctor Snyder and others, that tend to confirm or disprove these figures.

Coal is received in hopper-bottom on an elevated siding



Note the parts of these traveling-grate stokers designed for burning the extremely fine lignite





The pumproom with evaporator in background

The turbine room contains two 1,500-kw. units

6,000 B.t.u. 40% Moisture

Yet Lignite Gives

71% EFFICIENCY

in the Washburn Station

By G. W. Welch
Chief Engineer Otter Tail Power Company

It is something of a trick — until one learns how—to burn lignite at all, to say nothing of burning it with relatively high efficiency. Mr. Welch describes equipment and methods that have proved successful with North Dakota lignite at the Washburn, North Dakota, Station of the Otter Tail Power Company.

IN 1926 there was constructed for the Otter Tail Power Company at Washburn, North Dakota, one of the first power plants designed exclusively for operation on North Dakota lignite. The location of the plant was practically fixed at this point on the Missouri River by the natural features of an adequate and reasonably permanent water supply adjacent to railroad connections. The secondary consideration of proximity to suitable lignite deposits was met, there being several small mines within a distance of five miles, which could deliver considerable coal by motor truck. The main fuel supply, however, comes in by railroad from Wilton, a distance of eighteen miles and within the local freight rate zone.

The fuel burned is mainly lignite screenings or slack, which is largely dust, with coarse material averaging one-inch size. The heat value averages 6,000 to 6,500 B.t.u. per pound with 40 per cent moisture, 6 to 8 per cent ash, fixed carbon about 28 per cent and volatiles 27 per cent. The coal varies considerably in all values even from the same mine.

Previous experience with this fuel at another plant had shown that it was best handled on traveling-grate stokers, with special furnace-arch design to give ignition, which is the greatest problem in burning this coal. The advantages to be obtained by preheating the combustion air were recognized at the start, and the installation was planned accordingly.

Because of the high moisture content of the flue gases it was not considered advisable to use economizers or to cool the waste gases below their dew point, but, instead, to recover the available heat above this limit by means of the air preheaters. The losses in the waste gases are not a serious item with such a cheap fuel.

The coal handling was made simple and as nearly automatic as the size of the plant would justify. Coal is received in hopper-bottom gondola cars on a high level siding and switched on and off the elevated track hopper by an eight-ton gasoline locomotive. Unloading into the track hopper is by gravity dumping, with only hand cleaning of the cars necessary.

From the track hopper the coal flows by gravity to an underground crusher room, where it passes through a double-roll crusher to assure even sizing, then drops to the bucket elevator, which raises it to a point above the catenary bunkers, into which it is delivered by a lengthwise flight conveyor. From the bunkers the coal is drawn off by gravity through suitably located spouts to the traveling weigh larry in the firing aisle.

Ash is discharged continuously from the rear end of the stokers into suspended hoppers in the basement. From these hoppers it is sluiced periodically into a sump, from which it is pumped to the dump.

Inasmuch as most of the Dakota lignites do not clinker badly, the ash being mainly in the form of fine dust and granular material with only an occasional soft lump, the sluicing system is well adapted for handling it.

Two boiler units are installed, each of 5,000 sq.ft. These are of the multiple-drum, bent-tube type with the lower drums set twelve feet above the floor line. The operating conditions are 260 lb. and 175 deg. superheat. Multiple-loop superheaters are employed, the lower loops being extended down through the front tube bank so that some exposure to radiant heat may be gained, this being necessary on account of the low furnace and gas temperatures (1,600 deg. at 200 per cent in the furnace) realized with lignite. The air preheaters are of the ver-

tical tubular type, two-pass air and two-pass gas, an individual unit for each boiler being located directly at the rear of each setting. Gases and air both enter and leave at the bottom of the preheater. The air preheat temperatures are remarkably constant with this type of equipment and average 375 degrees.

Individual forced- and induced-draft fans, driven by variable-speed motors, are provided for each boiler, and the traveling-grate stokers, each with an effective grate area of 152 sq.ft., are driven by constant-speed motors through variable-speed transmissions. The arch design embodies a long front arch, nearly flat, with a short rear one, the throat between these arches being very narrow. No arch maintenance has been encountered to date, because of the low furnace temperatures.

Satisfactory ratings have been obtained in operation, and 225 to 250 per cent is frequently maintained for days at a time, the limiting factor to maximum forcing being the induced-draft fan capacities.

Combustion rates as high as 112 lb. per square foot of grade area per hour have been maintained without difficulty over considerable periods. The average B.t.u. rate per kilowatt-hour in this plant in 1927 was 28,000; in 1928 it was 27,000. An over-all boiler and furnace efficiency of 71 per cent has been obtained at ratings slightly below 200 per cent.

The boilers are inspected and cleaned at six-week intervals. Very little internal cleaning is necessary on account of using evaporated makeup, but there is always a considerable amount of fly ash to be removed from the gas passages and some slag on the front tubes and side walls. There has been practically no cleaning of the air preheaters, and to date no maintenance has been required.

Double-Effect Evaporation Supplies Makeup Water

Makeup is provided by a double-effect evaporator, using live steam in the first effect and condensing the vapor in a small surface condenser through which the boiler feed water passes. The evaporator system is, therefore, an integral part of the station heat balance. Evaporator makeup is pumped directly from the circulating water intake, passed through settling basins to remove sand and silt, and then goes to a small open feed-water heater which is supplied with exhaust steam from the auxiliaries, thence to the evaporator feed pump.

The cooling-water supply offered a number of problems because of the enormous quantities of silt and trash nearly always present in the Missouri River. There is an intake pier 75 ft. out in the river channel from which 30-in. inlet and discharge pipes are run underground to corresponding tunnels under the power house. Steel drop gates and coarse bar racks are provided for both pipes at the outer ends in the river pier. At the inner ends of the pipes, where they enter the tunnels, motor-operated Hunt gates are placed. At the front end of the inlet tunnel is placed a traveling screen of special fine-mesh ($\frac{3}{16}$-in.) baskets. The pump suctions have removable screen cages around the foot valves, and there are additional twin strainers ahead of the condensers and turbine oil coolers. The condensers are piped so that the direction of flow of the cooling water can be reversed for back washing.

All these features have been found necessary during high-water periods, when trash conditions are particularly bad. Circulating-water velocities have purposely been kept rather high throughout the system to prevent the formation of mud deposits. To date no trouble has been encountered from wear on circulating pumps due to the muddy water, and it has not been necessary to clean or replace any condenser tubes. Some trouble has been had at the intake with anchor ice during the autumn freeze up, but this can be cleared by steam jets.

There are two 1,500-kw. (at 80 per cent power factor) turbines direct connected to three-phase, 60-cycle, 2,400-volt generators. Two separate exciters are used, each unit of sufficient capacity for the station; turbine drive is employed on one and motor drive on the other. The main turbines are equipped with oil-pressure governors.

The condensers are of the two-pass surface type, each of 2,000 sq.ft. and designed for 28½-in. vacuum with 65-deg. cooling water. Each has its individual motor-driven circulating and condensate pumps and, in addition, there is provided a spare turbine-driven circulating pump of double capacity for emergency use. Air removal is effected by the usual type of steam-jet evactor equipped with inter- and after-coolers using condensate as the cooling medium.

The plant equipment has been so arranged that all auxiliaries are on the lower floor, only the evactors being placed alongside their respective turbines on the upper, or operating, deck, which is formed by a series of galleries on the same level that allow practically full

Equipment at Washburn Station

Boilers, two 5000-sq.ft. Badenhausen, 260 lb. pressure.

Superheaters, two Badenhausen, 175 deg. superheat.

Air preheaters, two Badenhausen tubular, 2,900 sq.ft.

Stokers, two Harrington 152 sq.ft. effective grate area, five air zones, Reeves drive.

Arches, Liptake double suspension.

Forced-draft fans, two Sturtevant "turbovane," direct driven by 25-hp. variable-speed Westinghouse motors.

Induced-draft fans, two Sturtevant "multivane," direct driven by 50-hp. variable-speed Westinghouse motors.

Copes feed-water control, Hagen combustion control, Bailey boiler and flow meters.

Coal equipment and bunkers furnished by Stephens Adamson Mfg. Co. Capacity 35 tons per hour. Main conveyor, V-bucket with roller chain drives, Westinghouse motors and Jones speed reducers. Car switching, Whitcomb 8-ton gasoline locomotive.

Turbine-generators, two Westinghouse 1,500-kw. (1,875 Kva.) 2,400 volts, 3,600 r.p.m., 3-phase, 60 cycles.

Condensers, two Westinghouse, 2-pass, surface type, 2,000 sq.ft.

Vacuum pumps, two Westinghouse, steam-jet with inter- and after-coolers.

Condensate pumps, two Westinghouse, single-stage centrifugal, motor drive.

Circulating pumps, two Westinghouse, single-stage centrifugal 2,650 g.p.m., 30-hp. motor drive.

Circulating pump, one Worthington single-stage centrifugal 4,000 g.p.m., driven by 60-hp. Kerr turbine.

Boiler-feed pumps, two DeLaval 3-stage centrifugal, 125 g.p.m. driven by 50 hp. DeLaval turbines

House-service pumps (raw water) two DeLaval single-stage centrifugal, 75 g.p.m., driven by 5-hp. motors.

High-pressure house pump, one Cameron, 2-stage, 750 g.p.m. 100 lb. pressure driven by a 75-hp. motor. Ash-pump and hydrojet system, one Allen-Sherman-Hoff, special 5-in. manganese steel pump driven by a 40-hp. motor.

Evaporator unit, one Schütte & Koerting double-effect, 2,400 lb. per hour.

Feed-water heater, one Cochrane deaërating, 45,000 lb. per hour.

Exciter, one turbine drive, Westinghouse, 35-kw., 125-volt, with 50-hp. Westinghouse turbine.

Exciter, one motor-driven, Westinghouse, 50-kw., 125-volt, with 75-hp. Westinghouse motor drive.

Traveling screen, one Chain Belt, 180 sq.ft. effective area, 33,000 g.p.m. capacity, driven by Westinghouse motor and James reducer.

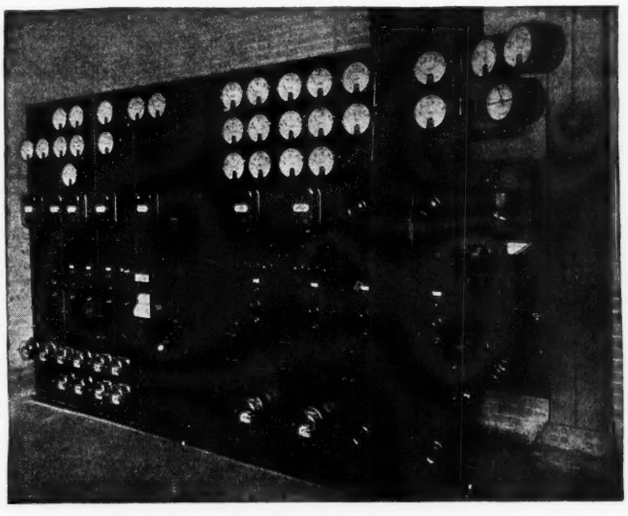
Switchboards, control equipment, oil switches, etc., Westinghouse.

Step-up transformers, 4 Pittsburgh, 1,000 kva. outdoor type, 2,300 delta to 22,000/38,100 Y voltage (one spare unit).

lighting and ventilation for the lower, or auxiliary, level and permit the auxiliaries to be served by the turbine-room traveling crane.

Electrical control is located in a separate operating or switchboard room, opening directly off the turbine room, on the upper-deck level. All high-tension buses and switching equipment are in a separate room directly under the switchboard room on the lower floor level. Switching of both high-tension and direct-current exciter circuits is handled by remote electrical control, as are also the main rheostats, with the result that there are no high-voltage or high-capacity circuits in the operating room. Control power is taken from a 60-cell, KXF-7, 120-volt storage battery in a separate battery room opening off the switchboard room. A small motor-generator set is floated across the battery to take care of the charging.

The station output is delivered at 2,300 volts to an out-



The switchboard room

door substation adjacent to the plant, where three 1,000-kw. air-cooled transformers step it up to the transmission voltage of 22,000/38,100 Y. Three outgoing three-phase lines take off from the high bus through air-break disconnecting switches and electrically operated outdoor-type oil circuit breakers. Oxide film arresters are provided on each line.

Station power and lighting at 440 volts three-phase and 110/220 volts three-wire, respectively, are supplied from separate transformer banks on top of the building, these being fed directly from the 2,300-volt station bus. Station power is distributed from a separate 440-volt switchboard on the auxiliary floor.

In the 2,300-volt main station bus a double system has been provided, employing an auxiliary or transfer bus which is energized from the main bus through a separate automatic oil circuit-breaker. Double-blade selector switches are provided on each outgoing line and plain disconnecting switches between the main bus and each individual breaker. By this arrangement any line may be transferred to the auxiliary bus without interrupting service and fed through the transfer switch, with full automatic protection, while its regular breaker is cut out by use of the disconnects for inspection or repairs.

The design of the plant was handled largely by the company's engineering department and construction work was handled by contract under the direction of the company's resident engineer, Charles A. Larson.

A Little Knowledge of Air Would Have Helped

By Earl Pagett

MANY things that require hard thinking and a lot of general knowledge confront an engineer and frequently he does not appreciate why some change in the machinery fails to give results. A case returns to my mind that may be used as an illustration and that may be worth describing.

In one industrial plant there was a central pulverized-coal preparing plant and an antique screw-conveyor transport system made of of hundreds of feet of large, medium and small screw conveyors. This system was so inefficient that the company finally decided to put in modern pneumatic transport equipment.

The manufacturer of the system was to furnish everything for its installation except the compressed-air machinery, and as the purchasing company had four compressors that were not in use, it expected to get by without further investment. These compressors had been used as gas-pressure boosters, and while they would handle a large volume, the air-cylinder pistons were about twice the area of the steam pistons. As the boiler plant was allowed only 90 lb. steam, air at 40 lb. was about the best that could be expected from them. The transport equipment company wanted at least 60 lb., and the mechanic for the purchasing company told his superintendent that the compressors were not suitable for the work. He was told to make them do the work anyway.

After the system was installed and tried, it was found that 40 lb. air pressure would do the work, but at so slow a rate that there was a continual howl from the pulverizer building for more air.

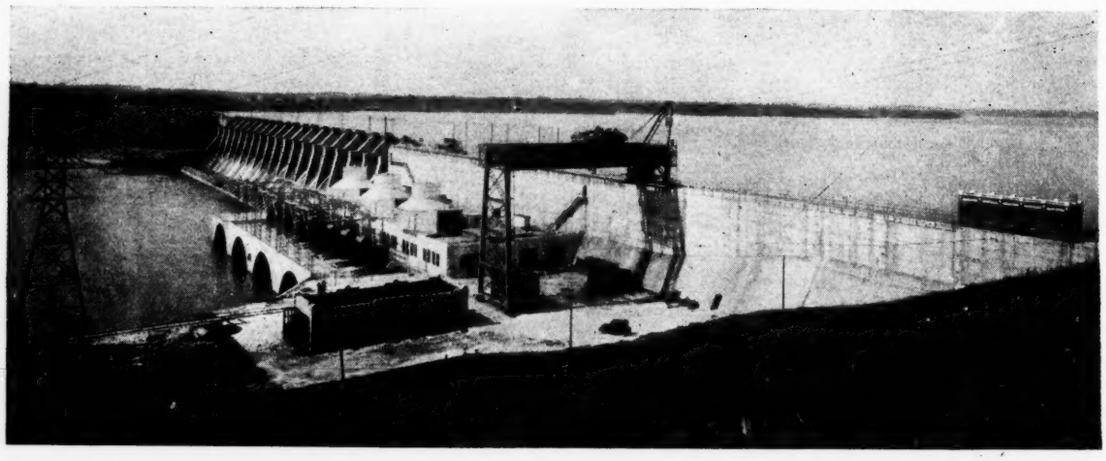
One compressor would make volume enough at 40 lb., and after some deliberation the mechanic decided that two of them should make enough at 80 lb. compounded. He had never seen this tried, but suggested it, and finally obtained permission to try it.

The piping between the two compressors was arranged, but the engineers found that the compressors would slow down and stop when the line pressure exceeded 40 lb. The mechanic now asked to be allowed to bush one air cylinder down to the same size as the steam cylinder, but he was overruled and a second-hand two-stage compressor was bought and installed. This compressor could not deliver enough volume, and the pressure would drop before the transport tank was empty. In an effort to hold up the pressure it was speeded to far above its rated speed and under these conditions it gave no end of trouble. A slug of water finally knocked out the cylinder head, and by this time everyone was willing to bush the cylinder of one of the old compressors, as the mechanic had suggested.

Accordingly, the air cylinder of one of the compressors not in use was sent to the machine shop, bushed down and a new piston made to fit. This allowed cylinders of the two to act as a compound unit, although the steam cylinders were independent of each other. It worked out in practice much better than would seem possible.

The writer was not sure at the time why only 40 lb. discharge pressure could be obtained without bushing one cylinder, but since thinking it over he has come to realize that since the two cylinders were equal, the first one merely discharged into the second at approximately atmospheric pressure. This was because the volume of air in the two cylinders remained unchanged.

WATER POWER . . .



Norwood plant of the Carolina Power & Light Company has three outdoor-type generators

. . . *Neither Bonanza Nor Goldbrick*

By F. A. Annett
Associate Editor, *Power*

Many claims have been made both for and against water power development. In this article these are evaluated and the relation between water power and steam considered.

OPINIONS on water-power development vary widely. Some attempt to prove our water-power resources to be of little consequence, while others claim they are our greatest single natural resource. Others insist that recent improvements in steam-plant operation and cheap fuel have put water-power development at a serious disadvantage. The opposite view also has many adherents.

Many seem to believe that because water runs down hill it does not cost anything and therefore water-power developments should pay extraordinary taxes and other charges to compensate the nation and states for the rights of development. There are also other schools of thought on water power, but the foregoing are representative. As some of the claims are contradictory all cannot be correct.

One of the greatest fallacies is the one that water for power development does not cost anything. As a general proposition is can be said that neither undeveloped coal lands nor water-power sites cost the public anything until they are utilized. It is the making use of these resources that costs. Coal is delivered at a steam plant at so much a ton. This cost includes charges for the investment in the coal lands, cost of mining, storage, transportation, etc. In this case the power-plant owner is required to pay for these facilities only as they are used.

In water-power development facilities for storing the water, transporting and delivering it at the plant must be purchased or constructed. All these involve large investments. It is not uncommon that water rights must be obtained for ten or twenty miles up a river to provide the necessary head at the plant, and storage facilities. This investment is much like that in a coal mine. Then works are necessary to make the water available at the wheels, and this requires investments in dams, tunnels, penstocks, control gates and other works. These correspond to the transportation facilities to deliver fuel to a steam plant. Therefore, instead of water being free, its cost per kilowatt-hour delivered at the wheels is comparable with that of coal on the grates in a steam plant. In the foregoing no account has been taken of the fact that most steam plants are near power distribution centers, while many water-power developments are long distances away from these centers.

As to water power being our greatest natural resource, this will depend upon the point of view. It is the only natural resource that is self-perpetuating. Therefore, it may be assumed that when other sources of power are exhausted, water power will still be available. Considered from this angle, there may be some justification for this rather extravagant claim for water power.

Those who would relegate water power to the limbo of no consequence and gold bricks can find little justification for such claims in the fact that over 40 per cent of the power supplied by central stations in this country last year was produced in hydro-electric plants. The remarkable feature about water power is that, notwithstanding the many obstacles placed in the way of its development, it continues to take an increasing share of the nation's power load.

The economic relation between steam and water-power plants is the subject of considerable controversy. Widely varying conditions influence this problem. In some sections of the country where water power is supplied over long transmission lines, it is required that steam capacity represent 75 per cent of the metropolitan load. Here it is not a question of water power competing with steam, but steam is a necessity to insure reliability.

For the foregoing conditions, where a large steam-plant program has been started, it may be found more economical to increase the steam capacity beyond 75 per cent of the metropolitan load before increasing the water-power capacity. The land for the steam-plant development is available for the entire project, and a large part of the investment for circulating-water and fuel-handling facilities and storage has been made. Therefore the plant can be extended for the costs of additions to the power house and generating equipment only.

On the other hand, a hydro-electric construction program might be partly completed and, to obtain more steam capacity, require starting construction work on a new site. Since the additional capacity can be obtained at the low cost of extending the hydro-plants, this would be the cheapest solution. In neither of these cases have the two sources of power competed with each other on an equal basis. In each, certain factors have given one a temporary advantage over the other.

Where long transmission lines are involved, reliability must be considered. Even when hydro-electric power is cheaper than steam, reliability may dictate that the steam plant be extended before the hydro development is made. Here it is a case of selecting a combination of steam and water power that will be the most economical, consistent with reliability.

There are other factors that influence the economic relation between steam and water-power plants, but the greatest obstacles to water-power development are those that have their roots in politics. Large developments could be made on the St. Lawrence and Niagara Rivers if the political and scenic beauty questions could be settled. A somewhat similar condition exists on the Colorado and other large rivers. In these the largest sources of water power in this country, political expediency rather than economics prevents their development.

Steam Power Versus Water Power

Cheap fuel, reduction in costs of steam-plant construction and improvement in the efficiency of these plants have had an important influence on the economic relation between steam and water-power plants. In 1920 the average fuel consumption was 3 lb. per kw-hr. for the central stations of this country. For the year 1928 in these plants the coal consumption dropped to 1.76 lb. per unit output.

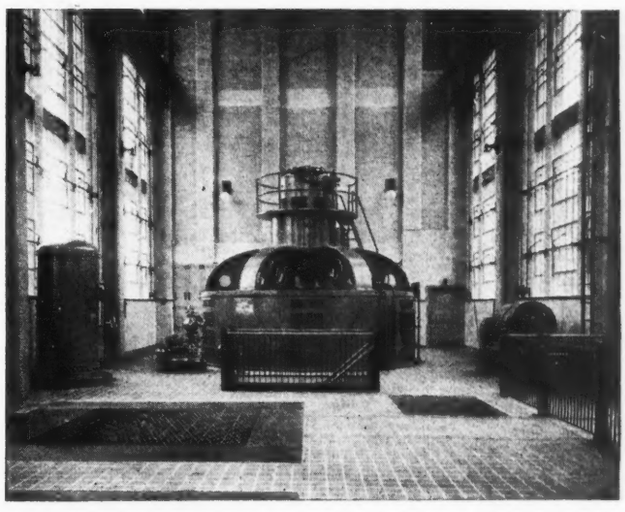
While these improvements were being made in steam plants hydro-electric plants also improved. The cost of construction has been reduced, more efficient units have been developed and the operating technic of the plants has shown advancement. Plant designs have been developed in which all the equipment is contained within the walls of the generator room.

Other stations have been designed with buildings just high enough to house the generators, the cranes being placed above the plants. In other installations the superstructure of the power house has been omitted entirely, the generators being provided with covers to protect them from the weather. Wheels of higher specific speed than formerly are being used. This has resulted in a material reduction in cost of the generating units and also in the power-house structures.

Placing the switching and transformer equipment outdoors has also reduced the cost of the plant. One of the big items of cost in many hydro-electric developments is the dam and waterway. Improved designs for these have also reduced the cost.

Probably the most important item in cost reduction has been improved methods of construction and better worked-out construction programs. These have not only reduced the actual cost of construction, but have materially shortened the time from the beginning of the work until the plant starts operating, resulting in a large saving in interest charges, and thus helping to keep down the total investment in the project. Of course there is a limit to which the speeding up can be economically carried.

Where large tracts of land are required for storage reservoirs, sites and rights-of-way must be obtained for long transmission lines. These involve large expenditures which are controlled largely by local conditions, and very little can be done to keep down the costs. Where railroads have to be relocated, bridges reconstructed and other changes and improvements made, the cost of the reservoir and the plant site may represent a large part of the total cost of the project. This fact places the possibilities of further materially reducing the cost of water-power projects at a disadvantage.



Generator in the Rocky River plant of the Connecticut Light and Power Company

This machine has a rating of 42,000 hp. and a large part of the water used for its operation is pumped by two 8,100-hp. pumps.

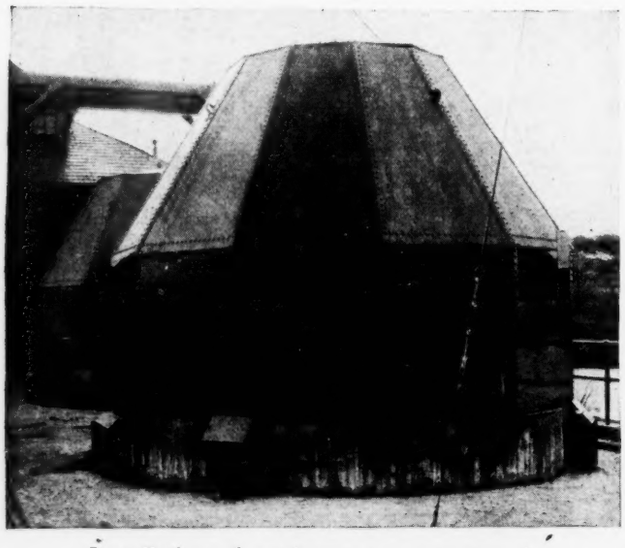
Although, during the last ten years, the efficiency of hydro-electric units has not improved as fast as that of steam stations, important gains have been made in the kilowatt-hour output per horsepower installed. In 1920 about 2,333 kw.-hr. were produced per installed horsepower in hydro-electric plants, while in 1928 this figure was over 3,400 kw.-hr., or an average increase of about 46 per cent.

Hydro-electric plant operators are now giving the same careful consideration to obtaining the maximum kilowatt-hours from a given quantity of water as steam-plant operators apply to the efficient use of fuel. This policy has produced results that a few years ago were not thought possible. Waterwheels are now carefully tested, and these tests are used as a basis on which to operate the plant at its best economy. In some plants venturi tubes have been installed in the penstocks, and in others the pressure differential across a change in penstock section is used to obtain a record on a venturi meter of water to the waterwheels. In this way a continuous check is obtained on the generating units' operation. Not only is careful attention given to the machines

operation, but the water losses when the machines are shut down are kept at a minimum.

Another factor favoring increased hydro-electric output per unit of installed capacity is increased rainfall during the last two or three years. Authorities are of the opinion that the valley of a 150-year rainfall cycle has been passed. If this is true, then a gradual increase in precipitation can be looked for, which will react favorably toward hydro-electric developments.

Interconnection of power systems has led to more efficient use of water-power plants. It has made it possible to develop large river-flow projects that could not otherwise be economically utilized. In periods of flood water the total capacity of the plant can be used on the base load. During low water the plant is used on peak-load service. Where a hydro project has daily storage capacity at the plant and is fairly close to load centers, it provides one of the most satisfactory and economical ways of carrying the peak loads. The units, when shut



Installation of outdoor-type generators in automatic hydro-electric plant

down, have no stand-by losses if they are properly installed and operated. They can be started in less than one minute, which allows the steam station to operate with less reserve capacity in service than if all the load were supplied by steam.

Interconnection of large power systems has brought large transmission lines within easy reach of water-power sites. This has made it economical to develop water powers that could not be utilized if a long transmission-line cost had to be included. Such plants on an interconnected system can in many cases be used to a much better advantage as kilowatt-hour producers than if they had to operate as independent systems.

There are many other factors that have an influence on water power in the nation's power program. There are sections of the country where, if economic laws were allowed to operate unhindered, water power would be cheaper than steam. In other sections steam-electric power is the cheapest. There are also large areas in which water will never be a factor in the power supply. Large industrial centers have been built up in regions having large resources of fuel. This is equally true of water power and for combinations of water power and fuel-burning plants. Both water power and steam plants have played important rôles in the industrial development of the country. In many sections the initial impetus to industrial development was available water power. Later in some of these localities steam-electric power provided a large part of the industrial sinew.

Water power has always occupied an important position in the nation's industrial development and always will. What is required by those who have control over its development is a realization that it is no bonanza and that more dividends have been paid by steam-plant projects than have ever been paid by water-power developments. Hydro projects cannot be developed if this entails all kinds of extortionate charges. Water power must compete with steam plants and is subject to the same economic laws. If governments would realize this and quit haggling over issues that do not get anywhere, millions of horsepower of water power now tied up in political controversy would be in operation or under development.

How Interpole Machines May Get Out of Adjustment

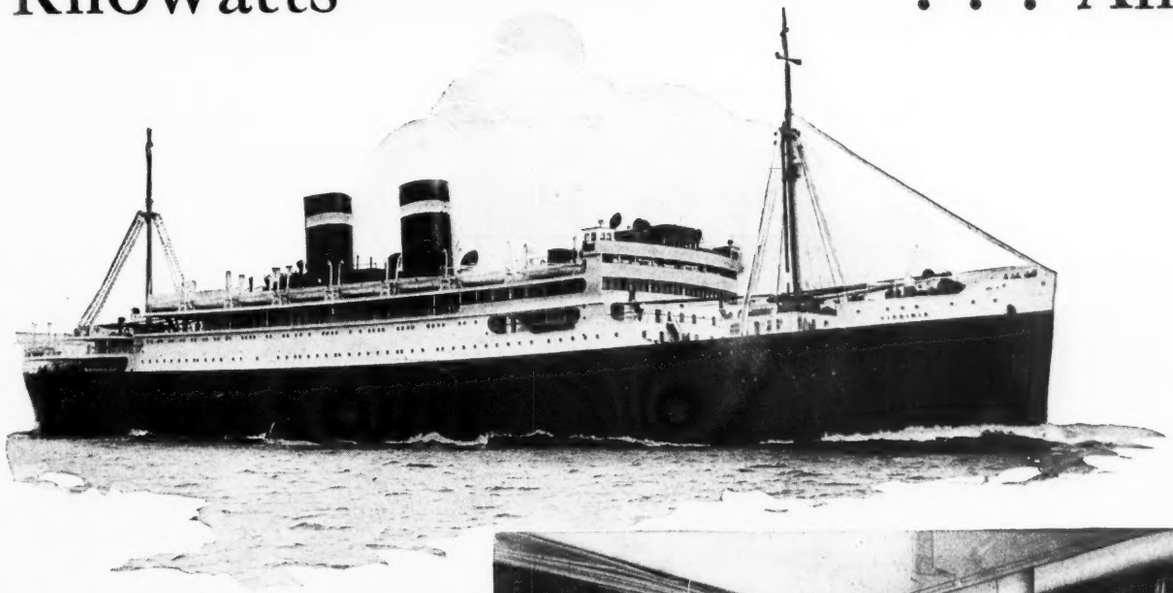
By B. A. Briggs

ONE thing often overlooked with interpole machines is that after they have been properly adjusted there are possibilities of their getting out of adjustment. The correct position of the brushes is usually marked, so that there is little doubt on this point. Where trouble is likely to be caused is by a variation in the strength of the interpole fields. A change in their strength can be produced by two causes—a variation in the current in the interpole field coils and wear in the bearings. When the strength of the interpoles is adjusted by a shunt across the field coils, the field current has two circuits, one through the coils and the other through the shunt.

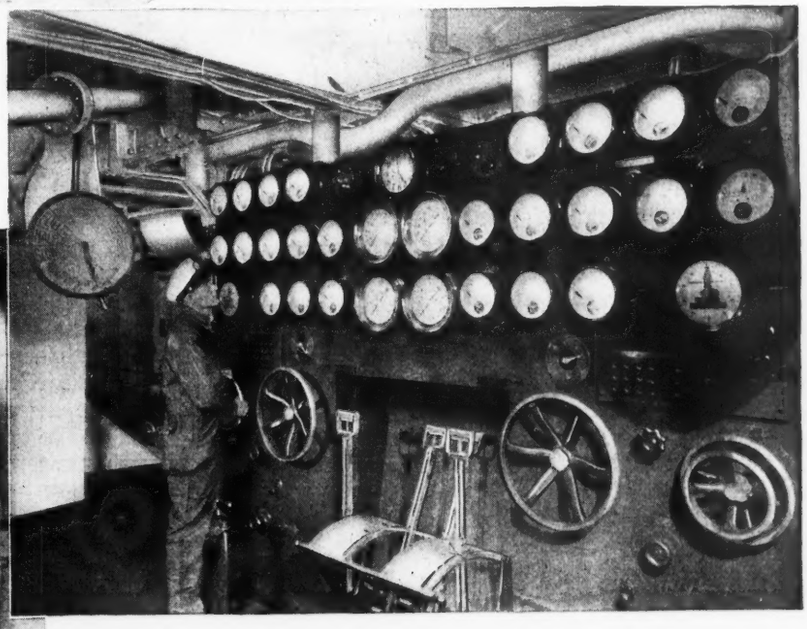
When the shunt is adjusted to cause the right proportion of the total current to flow through the coils, this adjustment may not be maintained. Loose connections between the field coils will increase the resistance of the coils and decrease the current through them. A poor connection to the shunt will increase the resistance of this circuit and cause the current to be increased in the field coils, for a given load on the machine. The former will cause the interpole field strength to be reduced below the correct value, and the latter will make the field strength too great and sparking at the brushes and other bad effects may result.

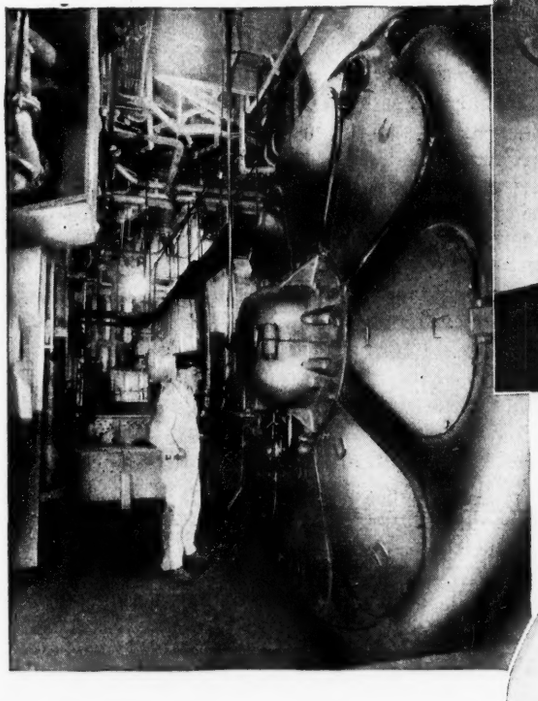
Wearing of the bearings changes the length of the air gap between the pole faces and the armature. As the bearings wear, the air gap at the top of the armature increases and that at the bottom decreases. This causes a decrease in the strength of the field poles on the top half of the machine and an increased field strength at the bottom. Both of these changes will cause sparking at the brushes, because of improper interpole field strength. An unequal air gap also affects the strength of the main poles and may cause circulating currents in the armature winding. These currents tend to make commutation more difficult. Therefore, on an interpole machine the air gap should be maintained equal. If sparking at the brushes develops, the air gap and the interpole coil and shunt connections should be checked. After these have been found correct, it will be time to look for other causes if the trouble still exists.

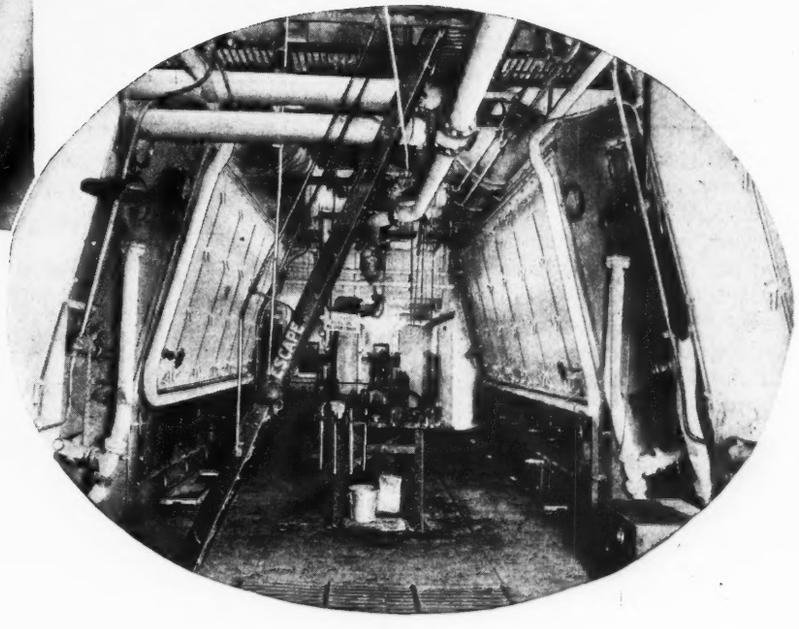
Kilowatts . . . Afloat



With turbine-generators aggregating 13,200 kw., the recently commissioned "Virginia" is the largest electrically driven passenger liner in the world







Photos show the oil-fired boilers, main switchboard and one of the 8,500-hp. motors driving the propellers. The "Virginia" was built by the Newport News Shipbuilding & Drydock Company to be used on the Panama Pacific Line of the International Mercantile Marine Company. She was electrified by the General Electric Company

COMBINING THE *Zeolite Softener and Deconcentrator* ... GIVES ... IMPROVED BOILER WATER

By Lucius A. Fritze
and
Elwood W. Scarrit
Respectively, executive engineer and chief chemist, Elgin Softener Corporation, Elgin, Ill.

ZEOLITE water softeners and the lime-soda system represent standard equipment now extensively used for the external softening of boiler water. The zeolite system is an exchange process, whereas the lime-soda softener is a precipitation method for temporary hardness and an exchange process for permanent hardness. The zeolite method converts all the salts of calcium and magnesium to soluble salts of sodium. The function of the lime-soda system is to remove a portion of the carbonates of calcium and magnesium, with the conversion of the permanent hardness to soluble concentration.

Disclosure of the potential danger of embrittlement from uncontrolled caustic in boilers, and the heavy caustic concentration created by the zeolite softener, initiated an investigation to determine the feasibility of controlling zeolite concentrations and thus permit the safe use of such equipment for softening boiler water. The purpose of this investigation was to establish a new standard by which the alkalinity could be utilized to profitable advantage and insoluble concentration substituted for the soluble, using deconcentrating equipment in combination with the zeolite softener. The scope of the investigation has been limited to boiler pressures under 250 lb., but the studies have included waters of mineral composition that would establish high alkalinity in boilers.

Parr and Straub, in their paper, "Embrittlement of Boiler Plate," published by the University of Illinois, have revealed the necessity of maintaining a definite ratio between the alkalinity and the sodium sulphate to prevent the development of embrittlement. Since the work on the benefits of tannates, phosphates and other salts is still in the experimental stage, the sulphate-alkalinity ratio has been used in the present investigation.

Conversion of the salts of calcium and magnesium to the soluble salts of sodium is the basic principle of the zeolite softener. The temporary and permanent hardness in a water are not subjected to differentiation in the zeolite process, for the salts of calcium and magnesium are replaced by their corresponding salts of sodium.

Natural waters, representing the major portion of the available supplies of this country, contain temporary hardness with varying quantities of permanent hardness. A limited number of sources supply water containing sodium bicarbonate with high silica, high iron, nitrates and other objectionable salts, necessitating special treatment for boiler use; but in most cases, the water supply available for boilers is a standard type of natural water.

Zeolite-softened water, when used for boiler-feed purposes, introduces soluble salts that concentrate within a boiler. The importance of the control of such concentration is emphasized by the development of uncontrolled caustic and the dangers involved. The substitution of sludge for soluble concentration, using deconcentrating equipment for its removal, has introduced a new method for boiler water purification.

By the zeolite process the temporary hardness, consisting of the bicarbonates of calcium and magnesium, is changed to sodium bicarbonate, commonly known as baking soda. Sodium bicarbonate in the boiler, under heat and pressure, breaks down to sodium carbonate and caustic soda. Calcium bicarbonate is limestone held in solution by combination with carbon dioxide. One pound of limestone will produce 1.68 lb. of sodium bicarbonate, equal to 1.06 lb. of soda ash or 0.8 lb. of caustic in the boiler. A water containing 7 grains of limestone per gallon will pro-

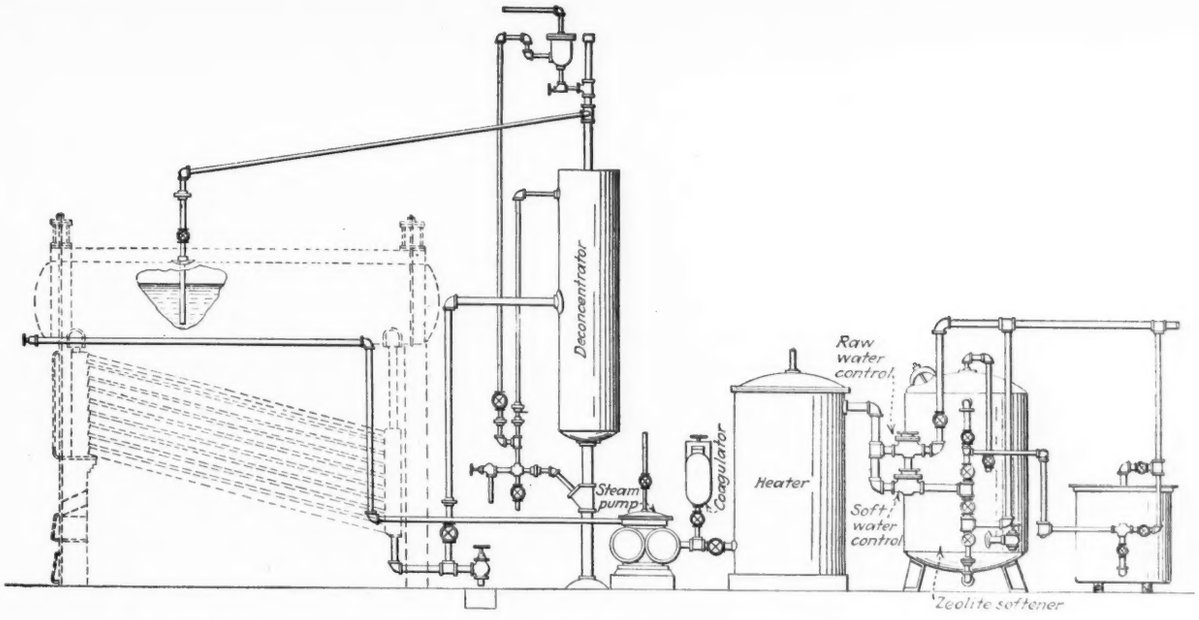


Fig. 1—Zeolite-deconcentrator combination with double meter control for proportioning soft and hard water

duce with each thousand gallons of water softened by the zeolite process, 1.06 lb. of soda ash in the boiler.

It is quite evident that the presence of but a small quantity of temporary hardness in the raw water will result in a high caustic concentration in the boiler and, unless controlled, presents a serious problem of soluble concentration leading to the possibilities of embrittlement, wet steam and wasteful blowdown.

In substituting sodium for the calcium and magnesium in the water, the zeolite method increases the weight of the dissolved salts. The amount of the increase is influenced principally by the quantity of magnesium present; but under average conditions the zeolite process increases weight of dissolved salts 10 to 12 per cent.

Water containing temporary hardness, wherein the balance between the alkalinity and sulphate content is insufficient to provide proper protection against embrittlement, requires treatment to increase the sulphate content. It has been customary in the past to use sulphuric acid or a soluble sulphate salt to provide the necessary sulphate-alkalinity ratio. Sulphuric acid, being highly ionized and difficult to proportion, introduces corrosion in the event of overtreatment, and its use is being discouraged.

Introduction of sodium sulphate to the feed water provides the desirable sulphate content and, being less dangerous, has found greater favor among operators. The use of other sulphate salts has not been encouraged in view of acid properties and higher costs.

It becomes apparent that existing methods for the control of the caustic concentration in boilers, to provide protection against embrittlement, are based on the principle of destroying the alkalinity by means of acid or by adding sufficient sodium sulphate to establish the desired sulphate - alkalinity ratio. The use of sodium sulphate introduces an additional salt which contributes to soluble concentration and intensifies the problem already aggravated by the exchange process.

In many waters the quantity of alkalinity is such that with high boiler pressure a critical point is reached wherein the addition of the correct amount of sodium sulphate produces a soluble concentration difficult to control, or, in the absence of an adequate sulphate ratio, protection is not provided against embrittlement.

The mixture of a definite quantity of zeolite softened water with the proper quantity of raw water will produce a satisfactory water supply of such character that the reaction in the boiler will form sludge or insoluble concentration. The alkalinity present in the raw water will be utilized as a softening agent thereby minimizing the quantity of alkalinity present in the boiler water and

The soda ash and caustic produced by the zeolite process are the same materials extensively used in the softening of boiler feed water. The lime-soda method uses soda ash for the permanent hardness, and the vast majority of boiler compounds contain soda ash or caustic, and in many cases, both substances.

If the zeolite softener is used to convert cheap table salt, sodium chloride, to the more expensive substances, soda ash and caustic, and the softening agents so produced are utilized in the softening of hard water, an improvement over present methods is realized. The destruction of the soda ash and caustic by means of sulphuric acid is wasteful and the addition of sodium sulphate builds up soluble concentration.

materially reducing the quantity of sodium sulphate required. The introduction of sludge in the place of soluble salts simplifies the problem of controlling concentration and establishing a desirable boiler water.

The reaction between the zeolite-softened water and the raw hard water will produce insoluble concentration, which under the present method of operation with the zeolite system, would present a problem as difficult to control as the soluble concentration. It is in the removal of the sludge so produced that deconcentrating equipment is required, and the control of the insoluble concentration makes the method practical.

Deconcentrator equipment is designed to circulate water from the boiler to a settling tank placed outside, wherein suspended matter will separate, and to return the clarified water to the boiler. Clarification of a boiler water by this means establishes within the boiler a definite concentration that is constant for each boiler. An equilibrium is maintained wherein the boiler water contains a definite amount of insoluble concentration and, with a feed water containing a definite quantity of sludge-producing matter the equilibrium with the boiler is held at a definite constant.

The quantity of water circulated from the boiler is equivalent to 25 to 50 per cent of the quantity of water evaporated per hour. Water producing a heavy concentration of sludge may require a greater circulation and, under severe conditions, it is possible to circulate to the settling tank 150 per cent of the hourly evaporation. The mixture of zeolite-softened water with raw makeup water will introduce sludge in proportion to the ratio of raw water added, and the requirements for circulation are easily established. Using a continuous blowdown system with heat exchanger to operate in combination with the zeolite softener, without bypassing raw, hard water, merely dilutes the soluble

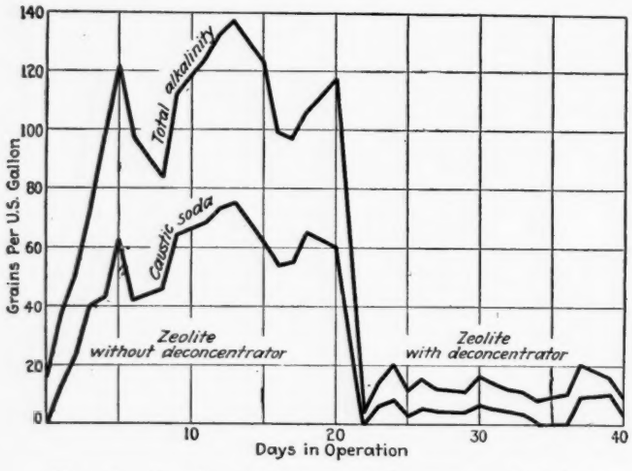


Fig. 2—Results of six-weeks' survey showing total alkalinity and total caustic soda for zeolite-softened water without and with deconcentrator

concentration within the boiler. In the absence of a proper sulphate-alkalinity ratio, protection is not provided against embrittlement, and the caustic within the boiler that could be used for softening hard water is wasted through the blowdown.

In the event that the zeolite water softener is operated in combination with the continuous blowdown system, with raw hard water bypassed in proper proportion, the highest efficiency is not realized for the reason that the continuous blowdown system is practical for soluble concentrations, whereas deconcentrator equipment is more desirable for insoluble concentrations.

The use of raw, hard water to reduce the alkalinity and to lower the operating costs for softening water, establishes a problem of controlling insoluble concentration and the equipment designed for such purposes is deconcentration apparatus. The benefits to be realized from the correct deconcentration of the proper mixture of zeolite-softened water with raw hard water are indicated in the results secured in field operation where the combination equipment has been in service.

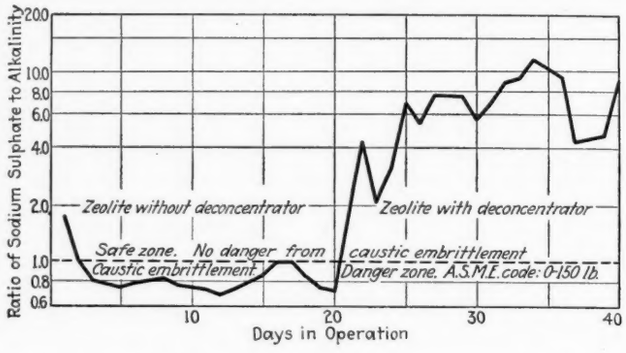


Fig. 3—Sulphate-alkalinity ratio from survey of Fig. 2

Concentration control secured by the zeolite-deconcentrator combination is illustrated by a survey made on a 1,500-sq.ft. horizontal return-tubular boiler operating at 125 lb. The test covered a period of six weeks under routine laboratory supervision, using a water containing a total hardness of 17 grains per gallon, composed of 87 per cent temporary hardness and 13 per cent permanent hardness.

During the first three weeks of the investigation all the makeup water was softened by the zeolite system, and during the last three weeks of the test the deconcentrator equipment was operated in combination with the zeolite softener. The accumulation of total alkalinity and caustic soda in the boiler is disclosed in Fig. 2. An initial concentration of 15 grains per gallon gradually increased within one week to an alkalinity concentration of 121 grains per gallon. Heavy blowdown was required to reduce the soluble concentration, but the alkalinity again reached 137 grains per gallon by the end of the second week.

Concentration of caustic soda in the boiler followed closely the alkalinity concentration. The maximum quantity was reached at the end of the second week in the amount of 75 grains per gallon, which was equivalent to over ten pounds of caustic soda for each thousand gallons of water in the boiler.

Following the three weeks' operation with all the makeup water softened by the zeolite process, the boiler was drained and washed. Upon placing it in service, a definite ratio between the amount of zeolite-softened water and raw, hard water was established and for a period of three weeks the ratio was maintained. The zeolite-softened water provided sufficient soda ash and caustic to soften the hard water bypassed, and the sludge produced within the boiler was removed continuously by the deconcentrator. Throughout the entire period the boiler water was maintained in a non-scaling condition, while the alkalinity never exceeded 20 grains per gallon, with the caustic content below 10 grains per gallon. A lower concentration of alkalinity and caustic could

have been maintained by increasing the quantity of raw water bypassed to the boiler.

An examination of the alkalinity curves for the six weeks' investigation shows that the zeolite-softened water alone produced a total alkalinity 585 per cent greater than during the period the zeolite softener was operated in combination with the deconcentrator. The caustic soda concentration produced by the zeolite softener during the first three weeks was 650 per cent

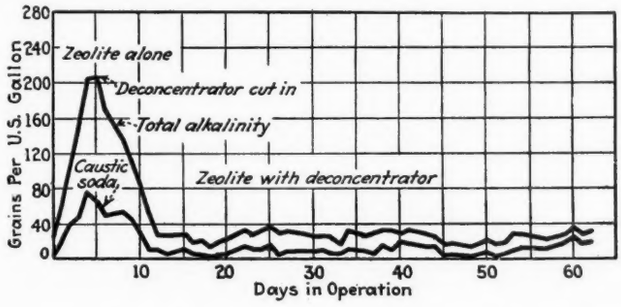


Fig. 4—Total alkalinity and total caustic soda for zeolite-softened water, as obtained in nine-week survey

greater than during service of the combination system.

It is evident that if an attempt had been made to prevent embrittlement by the use of a correct sulphate-alkalinity ratio during the first three weeks of the investigation, the boiler water would have contained a high concentration of soluble salts with a corresponding increase in blowdown. It is to be noticed further that, during the period the combination system was in use, the low alkalinity would have permitted the maintenance of a proper sulphate-alkalinity ratio, with the addition of but a small amount of sulphate, if the raw water had contained no sulphate salts. The raw water used in the investigation, however, contained 8 grains of sulphate salts; and it is of interest to notice in Fig. 3 the sulphate-alkalinity ratio maintained during the test period without the introduction of additional sulphate salts.

In accordance with the A. S. M. E. Code for boilers operating below 150 lb., the ratio of sodium sulphate to alkalinity should be at least one to one to prevent embrittlement. If the ratio falls below one, embrittlement may be expected to develop.

Fig. 3 shows the sulphate ratio—first, when the makeup water consisted of zeolite-softened water alone; and, second, when the makeup water consisted of the proper mixture of zeolite-softened water and raw water. The use of the zeolite-softened water alone caused an increasing concentration of alkalinity, with the sulphate ratio below one; and the curve remained in the embrittlement danger zone. The use of the deconcentrator system during the last three weeks, with the correct ratio of zeolite-softened water and hard water, reduced the alkalinity, permitting the sulphate ratio to increase. The curve in this latter case ascended above the embrittlement zone.

This survey disclosed that, although a boiler using zeolite-softened water developed an excessive alkalinity conducive to embrittlement, the same boiler, equipped with deconcentrator equipment and using the proper ratio of zeolite-softened water with raw hard water, produced less alkalinity. This set-up provided protection against embrittlement without the introduction of additional sulphate salts.

Further confirmation of the control of alkalinity with zeolite-softened water is disclosed in a second survey made on a 1,500-sq.ft. return-tubular boiler operating at 150 lb. The test covered a period of nine weeks, using 100 per cent makeup water, the raw water containing a total hardness of 26 grains per gallon composed of 68 per cent temporary hardness and 32 per cent permanent hardness. The boiler was clean when placed in service. During the initial five days the makeup water consisted of zeolite-softened water alone.

Fig. 4 shows the alkalinity and the concentration of caustic soda that developed in the boiler. Within five days the total alkalinity reached 207.5 grains per gallon, equivalent to 29 lb. of soda ash and caustic for each thousand gallons in the boiler. At this point the use of zeolite-softened water was discontinued and raw, hard water, without treatment, was introduced. The use of raw, hard water alone continued for a period of six days, and during this time the excessive soda ash and caustic that had accumulated within the boiler provided sufficient softening reagents to soften the raw water. The sludge produced by the reaction within the boiler was withdrawn through the deconcentrator, and the reduction in total alkalinity for the period from the sixth to the twelfth day is indicated in Fig. 4. Beginning with the twelfth day a definite mixture of zeolite-softened water with raw, hard water was used for feedwater purposes, and during the following 51 days the zeolite-deconcentrator combination was operated with the predetermined mixture.

The control of the alkalinity as the initial step in the prevention of embrittlement is disclosed by the sulphate-alkalinity ratio indicated in Fig. 5. For the first five days, when the zeolite-softened water alone was in use, the sulphate ratio remained considerably below one and within the embrittlement danger zone. On the sixth

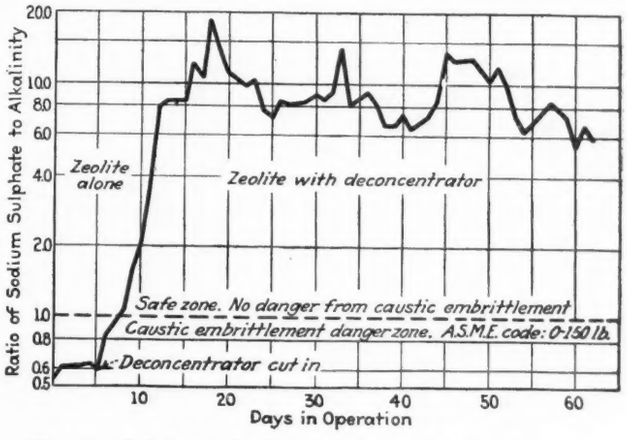


Fig. 5—Sulphate-alkalinity ratio in nine-week survey

day of the test, as soon as raw, hard water was added, the sulphate ratio increased. As the point was reached when the proper ratio between the zeolite-softened water and the raw, hard water was established, the sulphate-alkalinity curve ascended to a point considerably above the embrittlement danger zone and remained at a safe value during the following 51 days.

Addition of a larger quantity of raw water for mixture with the zeolite-softened water would have reduced the alkalinity and caustic soda content of the boiler water; but, in view of the satisfactory sulphate-alkalinity ratio the proportions of the mixture were not altered.

A Good Oil is Necessary for a Steam Turbine

THE increasing outputs for which high-speed steam turbines are being built impose much greater stresses on the bearings, and the requirements placed on the lubricating oils have been increased to a corresponding degree.

While the oil is circulating in the oil system of the turbine, decomposition phenomena occur which tend to change the properties of the oil. It has been found that the speed at which this "aging" process, which must be attributed to oxidation, takes place varies with different kinds of oils according to the sources from which they are obtained and the degree to which they have been refined. Thus the extent to which the oil can change during service varies considerably.

Aging of Oil

Until a few years ago the aging was not taken into consideration when testing oils, and the acceptance tests were usually made on the oil as it was delivered. Engineers tried to produce the aging by means of the same artificial oxidation used in determining the tar figure, and the tar figure itself was taken as the criterion of the quality of the oil. In an article in the *Brown Boveri Review* it was pointed out that these methods of testing are not sufficient to reproduce phenomena capable of being compared with the aging process, and that these cannot, therefore, be completely comprehended.

As a result of large-scale service tests extending over several years, carried out on various turbines by the Verein Deutscher Eisenhüttenleute in co-operation with the Vereinigung Deutscher Elektrizitätswerke, it was concluded that it is inadequate to test steam-turbine lubricating oils only in the condition in which they are supplied, as the properties can change considerably during service due to the aging of the oil; and that the artificial oxidation employed in determining the tar figure is not sufficient to reproduce the aging process.

Brown, Boveri & Co. have conducted tests regarding the aging of oils and have thoroughly investigated the products of the reaction and the accompanying changes in composition. It was found that when mineral oils decompose during service, oxidation products are formed; some are soluble in the oil, but others form a more or less solid sludge, which may choke the oil coolers. The reaction products contain polar or active groups, which, owing to the alteration in the molecular forces, can change certain properties of the oil. Thus, for example, the cohesive force, and therefore the stability of the oil film, is increased by the molecular groups of these reaction products.

Effect of Cohesion

Its viscosity also increases. The cohesive force itself, however, is not directly connected with the viscosity, although, on the other hand, these molecular groups alter the saponification value and its consistency. The tendency to emulsify is also increased. It was shown that the acid-reaction products are not alone sufficient for the formation of emulsions, and that neither the acid value nor the tar figure is an accurate indication of the way the oil will behave in service. The emulsification cannot be determined by such arbitrary methods, which are very frequently used in the testing of oils.

The surface tension with respect to certain liquids is not a reliable criterion for the emulsification. The acknowledgment of this fact disperses the old theory that emulsions are caused by saponification. This theory can also be shown to be false by the fact that very stable equilibrium between emulsions has been achieved when using pure distilled water.

Even though, in certain special cases, saponification is an important adjunct to the formation of emulsions, in the majority of cases the building of the separation film and the formation and arrangement of the polar groups within that film are of greater importance. According to the research mentioned, the method of testing turbine oils by means of salt solutions, as employed by certain marine companies, is fundamentally incorrect, because the formation of emulsions is not aided by the salt solution. Emulsions are, rather, broken down or destroyed by its action.

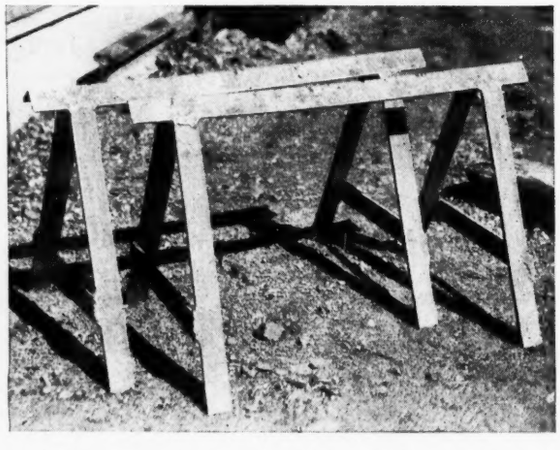
A properly designed turbine bearing should increase the maintenance of a perfect oil film if the viscosity is correct. The correct viscosity depends, of course, on the mechanical and operating conditions of the particular machine.

Standard Specifications

Brown, Boveri & Co. have therefore laid down specifications for turbine oils, based on the results of their experiments. The greatest value is laid on the artificial aging test. The method of determining the resistance to oxidation has been developed as the result of experience and by making comparisons between laboratory tests and practice, but has not yet been perfected.

TURBINE OIL SPECIFICATIONS

Specific gravity at 68 deg. F., not over		0.93
Flash point in open crucible, deg. F.		338
Fire point in open crucible		410
Acid value, not over		0.1
Viscosity at 68 deg. F., Saybolt sec		1,200
Viscosity at 122 deg. F., Saybolt sec		121.8 to 193.8
Viscosity at 178 deg. F. Saybolt sec		48.1
Ash content, per cent		0.1
Asphalt content		0
Fatty oils content		0
Aging Tests	On Delivery	After Aging
Acid value	0.1	0.3
Saponification value	...	Not over 1.5
Sludge content	...	0
Emulsification in distilled water	0	0
Emulsification in a 1 per cent soda solution	0	0



These "iron horses," unlike those used in railroad pioneer days, but equally well adapted to the job they are intended to perform, were fabricated from "ells" and flat bars by oxyacetylene welding. The photograph was obtained through the courtesy of the Linde Air Products Company.

Some Causes of

MOTOR SHAFT FAILURES

By Edward Ingham
Mechanical Engineer, Manchester, England

FAILURES of electric-motor shafts are caused by (1) faulty material, (2) faulty design and (3) out of alignment. Motor shafts are usually made of high-class mild steel. Sometimes, however, the steel contains impurities that render it unreliable. Of these impurities, sulphur and phosphorus, unless present in very small quantities, will seriously impair the metal's qualities. Occasionally, the material is weakened through unsatisfactory heat-treatment during manufacture.

In two recent shaft failures investigation showed the shafts to be made of low-quality wrought iron, unsuited for the purpose. Wrought-iron shafts have now been

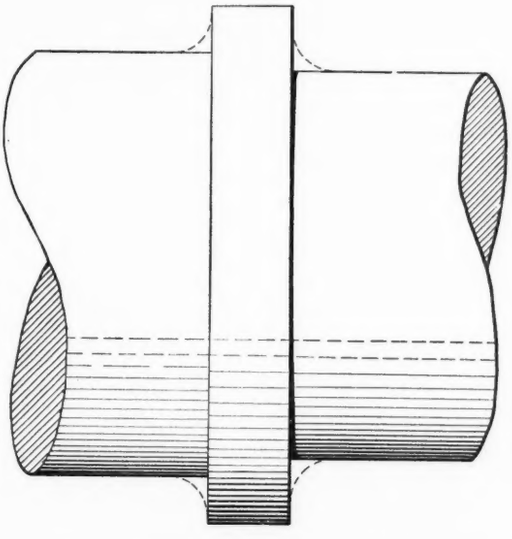


Fig. 1—Sharp corners should be avoided where shafts change diameter

almost entirely superseded by mild steel. In some instances shaft material has been adversely affected by welding. The intense heat of the welding flame alters the structure of the metal, which should be heat-treated to restore it to the original condition.

Where there is a change in a shaft's diameter, as in Fig. 1, sharp internal corners should be avoided. Sharp corners cause localized stresses and tend to cause fractures. This can be prevented by rounding the corners to as large a radius as practicable, as shown by the dotted curves. Roughness on the shaft should also be avoided. Rough-turned shafts are more likely to develop fractures than are those with a smooth surface. The tool marks form small grooves where stress concentration occurs and where fractures may develop.

Selecting a shaft size to transmit a given horsepower is a simple matter, and rarely is it too small for the purpose intended. Too often, however, the load is gradually increased until the motor is heavily overloaded, which has caused shaft failures.

When a shaft is out of alignment, it is subjected to severe bending strains. A shaft worked under such conditions is almost certain to fail sooner or later, consequently shafts should be maintained in true alignment. Many failures occur in connection with shafts supported in three bearings; that is, an outboard and two main bearings. Unless all these bearings are in true alignment, severe strains will be set up. Sometimes the shaft is thrown out of alignment by uneven wear of the bearings. In one instance the outboard bearing was located in an atmosphere charged with dust and gritty particles. The dirt got into the lubricating oil and caused rapid wear

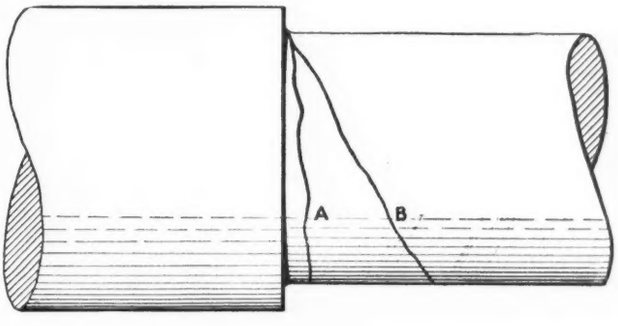


Fig. 2—Cracks may develop at right angles or diagonally with the axis of the shaft

of the bearing. As a result, the shaft was thrown out of alignment and failed.

Occasionally, the trouble is caused through uneven yielding of the foundations. In the case of concrete foundations, yielding has occurred through installing the motor before the concrete had time to set thoroughly. Oil has a deleterious effect on concrete and certain jointing materials used in foundations, causing softening and disintegration. This should be avoided if the bearings are to remain in alignment.

In one instance the nuts worked loose on the bolts securing the motor to its foundation. The driving belt tension turned the machine through a slight angle. As the motor shaft was connected through a solid coupling, the twisting produced a severe strain on the shaft, which caused a fracture. There are various ways a shaft may be thrown out of alignment, and it is advised that they should be tested occasionally by someone specially qualified to do such work.

In some cases the alignment of the shaft has been

affected by faulty fitting of couplings, gear wheels, etc.

Lack of lubrication may lead to serious overheating of shaft journals, which may cause cracks, especially if the attendant resorts to cooling the bearings by pouring cold water over them.

Cracks in good steel shafts usually develop slowly, therefore serious consequences may generally be avoided by regular inspection. Periodic examinations will serve to discover a crack as soon as it appears, and the defect can then be watched for signs of extension. Considerable experience with machinery, combined with sound judgment, are necessary to decide whether or not a cracked shaft should be allowed to run, and the matter is therefore one that can be satisfactorily decided only by an expert.

As might be expected, cracks commonly run in a nearly circular direction, as *A* Fig. 2, which shows a crack that has started at a sharp internal corner. Sometimes, however, they run in a diagonal direction, as at *B*.

Occasionally, what appear to be cracks or fractures are found running in a longitudinal direction. These are usually simply dirt and reed marks and are most likely to be met with in wrought-iron shafts. They are not as a rule serious. A longitudinal crack is not nearly so dangerous as one running in a circular or diagonal direction.

Fractures are often extremely fine and are likely to be overlooked. Hence, the inspection should be done carefully, particular attention being devoted to parts where there are internal corners or changes of diameter. Cleaning the shaft and using a large reading glass will greatly facilitate the inspection work.

Credit should have been given to *Engineering* (London) for the illustration, Fig. 1, that appeared in the Nov. 6, 1928, number of *Power*, and showed a cross-section of the Pawlikowski powdered coal engine. While the illustration used in *Power* was substantially the same as that given in the American patent specifications, it was actually reproduced, with slight changes, from that appearing in *Engineering*.

"How Much Goes Up the Chimney?"

The answer in dollars and cents can be found from a chart prepared by David Moffat Myers, which will appear next week in *Power*.

The author shows how continuous control of preventable boiler losses through intelligent operating methods can effect substantial savings with existing equipment.

Electrical Wizardry in Soviet Russia

ELECTRIFIKATZIA (electrification) is the Abracadabra of the Communist magicians. At the wave of their potent wands toward the adze-hewn rafters of the miserable *muzhik* hovels, there miraculously appears dangling therefrom, not the conventional white rabbit, but something that is a thousand times more wonderful than any beast of flesh and blood—an incandescent lamp.

Possibly the utility of the innovation does not strike the peasant quite so forcibly, at first, as does the fact that he has been given something that has hitherto been enjoyed solely by the aristocrat and the landed farmer. Consequently, he is filled with profound respect and admiration for the institution that has effected so radical and apparently impossible a reverse of the long accepted natural order of things.

Perceiving an advantageous reaction to the "bottled light" among the class on which it was most anxious to make a favorable impression, the Communist Party, early in its career launched an electrification campaign the magnitude of which is best illustrated by the lately published official report.

Salient items in a summary of economic statistics are figures for the Soviet Union fiscal year 1926-27, showing a total capacity of 740,000 kw. with an output of 4,050,000,000 kw.-hr., as against a capacity of 328,000 kw. and an output of 1,945,000,000 kw.-hr. for the year 1913.

During the last five years a number of public-utility and factory power plants have been built on the territory of the Union, many of them utilizing water power and others designed for operation on peat and lignite. The largest of these is the Volkhov installation with 55,000 kw. capacity. In addition to the plants already completed, there is another group in the process of construction with a projected aggregate capacity of over 2,000,000 kilowatts.

A list of the major installations completed within the five-year period is as follows:

Installation	Present Capacity, Kw.	Projected Capacity Within Five Years, Kw.
Volkhov	55,000	Same
Krasny Oktabr	20,000	108,000
Shatura	48,000	136,000
Kashira	12,000	122,000
Elektroperedatcha	36,000	56,000
Balakhna	20,000	86,000
Shterovka	20,000	108,000
Kizel	6,000	44,000
Zemo-Avtchal	13,000	15,000

Future power projects have the following imposing funds of hydraulic energy and fuel upon which to draw:

(a) Undeveloped water power	62,000,000	hp.
(b) Timber	2,000,000,000	acres
(c) Coal reserves	474,000,000,000	metric tons
(d) Oil	2,883,000,000	metric tons
(e) Peat reserves (Europe only)*	37,250,000,000	metric tons

*Total area for peat in Union 325,000,000 acres.

State industries have also ventured into the manufacturing field and announce a production of commodities which have heretofore, been either imported or produced in negligible quantities. Not the least important among these are items of electrical equipment, namely: Turbo-generators up to 10,000 kw. capacity; high-voltage motors; oil switches; electric irons and other utensils; signal equipment; transformers of large capacity cable; automatic telephones; incandescent lamps; radio goods, etc.

Notes on Heat Value of Fuel Oils

By H. L. Kauffman
Petroleum Consultant, Denver, Colo.

THE questions relative to the heat value of fuel oils asked in a letter recently received from the executive of a public utility company, and the answers to them, the writer believes will be of interest to readers. The questions asked were:

1. Is it possible to determine the B.t.u. value of a fuel oil from the gravity?

2. Is there any difference between the heat value of an uncracked and a cracked fuel oil of the same gravity?

3. What factors affect the B.t.u. content of a liquid fuel?

4. Should fuel oils be purchased on a specification of B.t.u. per pound or per gallon?

To these the writer replied as follows:

1. Yes, it is possible to determine the B.t.u. value of a fuel oil from the A.P.I. (American Petroleum Institute) gravity. The following equations, representing the relationship between the A.P.I. gravity of either uncracked or cracked residuum and its fuel value, were developed by Faragher, Morrell and Essex and were given in a paper presented by them at the September, 1928, meeting of the American Chemical Society:

B.t.u. value of uncracked fuel oil per pound of oil = 17,660 + 69 deg. (A.P.I. gravity).

B.t.u. value of cracked fuel oil per pound of oil = 17,780 + 54 (A.P.I. gravity).

In the first equation 17,660 and 69 are constants that have been determined experimentally; while the same is true of the numerals 17,780 and 54 shown in the second equation.

2. Yes, there is a difference between the heat value of an uncracked and a cracked fuel oil of the same gravity. At 10 deg. A.P.I. a cracked residuum has substantially the same fuel value as a 10 deg. A.P.I. uncracked fuel oil; but as the A.P.I. gravity increases, the difference in B.t.u. value of the two fuels enlarges until at 30 deg. A.P.I. there is a difference of 300 B.t.u. per pound of oil. There is no apparent difference between the fuel value of a flashed residuum made at two pressures and a normal residuum made at high pressures, so long as the gravities are the same; however, the former usually possesses a lower A.P.I. gravity and a lower fuel value than the corresponding normal residuum.

3. The main factors affecting the B.t.u. value of a fuel oil are the moisture content and the sulphur content; hence, all calculated B.t.u. values should be corrected for the presence of these constituents. One per cent of B. S. material (residue) as shown by the A.S.T.M. benzol-centrifuge method is equivalent to approximately 10 B.t.u. Uncracked fuel oils usually show less than one per cent of such material, whereas some of the cracked residuums may show comparatively high percentages, a condition that can be alleviated by proper methods of operation. There does not seem to be any connection between heating value and other characteristics of fuel oil, such as volatility, source of the crude from which the fuel oil was obtained, coke-forming tendencies, B. S. content as determined by the benzol-centrifuge method and carbon hydrogen ratio.

4. The B.t.u. value per gallon of an oil decreases as the A.P.I. gravity increases, a condition that is just the opposite from the B.t.u. value per pound of oil. Consequently, oils of low gravity (and, likewise, of low price) contain a lesser number of B.t.u. per pound, but more B.t.u. per gallon. *Since the gallonage basis is the customary basis of purchase, it is an advisable practice to purchase fuel oils on a specification of B.t.u.'s per gallon.*

The Skyrocket as a Power Generator

By Donald McFee

ACCORDING to the daily papers a late engineering development in Germany is an automobile that is propelled by the ejection of gas from orifices in the rear. This "rocket" motor is said to be fed with gunpowder, and it is expected to reach unprecedented speeds. The car, however, is regarded as only a first step toward the higher goal of airplanes and airships driven in the same way.

Jules Verne dreamed about this development long years ago and described a trip to the Moon in a vessel designed like a skyrocket. The idea seems to be attractive to inventive minds. The Patent Office records numerous designs of rail cars driven by backward jets, and in many cases the inventor provides a series of stationary paddles along the track, to give the jets a toe hold on the earth, as though they might thereby push harder, after the fashion of a boatman's pole or the broomstick plied by a small boy pushing his toy wagon.

It is foolish to say that anything will never work, and perhaps we shall some day ride about on rockets. But it is pertinent to remark that there is an inherent limit to the efficiency of such a device. To push the vessel ahead, it is necessary to accelerate the issuing gas until it attains a rearward velocity greater than the forward velocity of the vessel in inverse proportion to its smaller mass, and the kinetic energy thereby imparted to the gas is wholly lost. Of course it may be that when speed is the sole object, efficiency may not count so much.

Power for pulp and paper mills in Canada aggregates 1,355,000 hp., of which 1,071,873 hp. is hydro-electric and the remainder direct hydro drive. This is over 28 per cent of the total water-power installations in the Dominion. The power purchased in 1928 by the pulp and paper industry amounted to almost one-third of that produced for sale by central electric stations. There was paid for this approximately $11,500,000. It is evident that the pulp and paper industry has an extremely important relationship to the water-power industry in Canada. The use of steam as a source of power for this industry is small, the total installation amounting to only 120,352 hp., or 8.2 per cent of the total power installation. Steam installations are usually prompted by special conditions, such as operation in connection with the manufacture of lumber when refuse can be used as boiler fuel.

Comparing a 400-lb., 900-deg. F. plant with one operating at 1,000 lb., 700 deg., H. L. Guy, in a paper before the Institution of Mechanical Engineers (Great Britain), claims 3.9 per cent greater efficiency for the former, without considering feed heating, and slightly over one per cent with four-stage feed heating. Furthermore, the author shows that for a given material the creep would be the same under the two conditions.

Right Out of the Plant

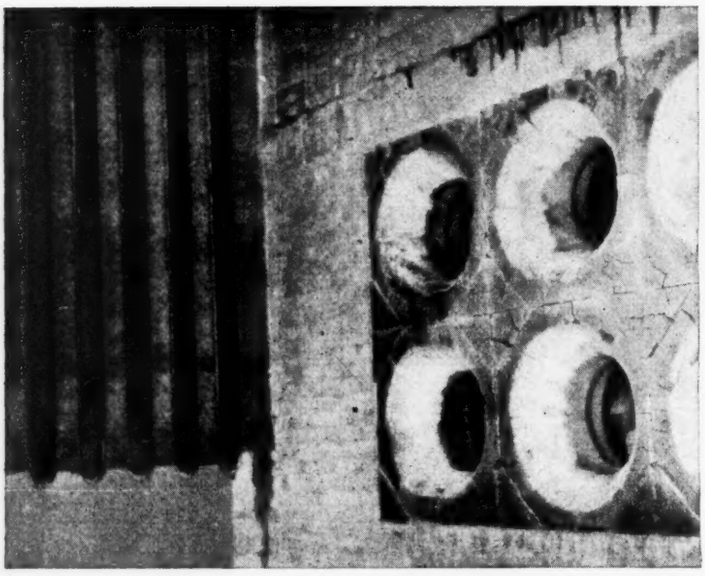


Fig. 1—Section of side and front walls, with burner group after 5,000 hours' operation

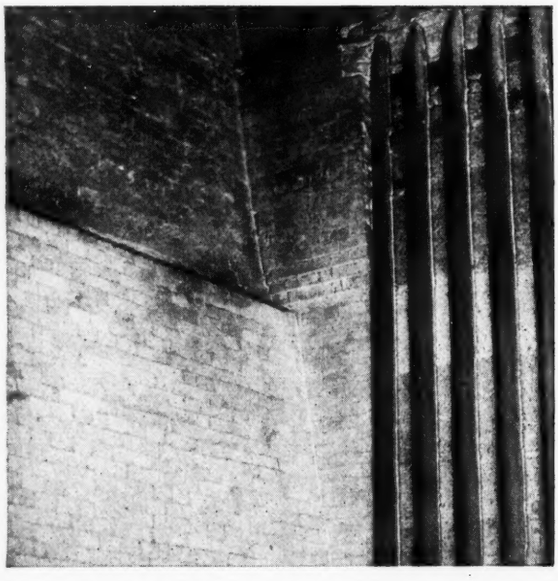


Fig. 2—Section of rear and water-cooled side wall

Low-Cost Furnace Construction Gives Excellent Results

SINCE writing the article entitled "Low-Cost Furnace Construction Gives Excellent Results," which was published in the Feb. 19 number of *Power,* we have had an opportunity to go into the furnace and make a close inspection of the refractories. We found them to be in practically perfect condition. Three photographs, two of which are reproduced herewith, were taken at that time and show the condition of the brick and plastic after five thousand hours of service, about 90 per cent of which was on natural gas and the rest on fuel oil.

Pasadena, Calif. O. H. HENDRICH, Mech. Eng.
Municipal Light & Power Department.

Going Over the Chief's Head

I WAS much amused at the answers to the question asked the readers in the Jan. 1 issue as to the policy of going over the chief's head. Each one seemed to devote a lot of time to considering the chief's feelings.

One's first reaction is to think that one should never go over one's immediate superior to place a suggestion before the management. A sense of loyalty seems to forbid such a breach of the relationship that should exist between an operating engineer and his chief. This step, so the world proclaims, violates the principle of loyalty.

But why should the employee always be confronted with this obstacle, loyalty? Is not the word like hundreds of others, an idle gesture?

Like charity, loyalty begins at home and a man is not being true to himself if he allows a sense of loyalty to others to hinder him in his progress in life. Self-preservation is the law of society as of the jungle, and it is this law that prompts a chief engineer to hold down his subordinate. Why should not he, the subordinate, likewise invoke the law?

A man must get on in this world to retain his self-respect. If a chief engineer stands in the way, one is not justified in delaying one's upward progress by stopping even a minute to pity the chief.

With this logic as a background, I would say that an operating engineer should, as a matter of caution, first present his idea to his chief. If he turns it down and if it still looks good, a plan of campaign should be worked out.

The first step is to decide whether the matter is of sufficient moment to be made an issue. Is the operator willing to risk the loss of his present job in case the management turns him down? For he may rest assured that his neck will feel the chief's ax if the management is not sold on the idea. If the operator desires success with his whole soul, he will not hesitate, provided the idea is a big one.

Now many ideas are good but not of sufficient value to be made an issue. In this case the operator should put his idea on paper and submit a copy to his chief; when next an idea occurs, a similar process should be followed. Finally, when the "big" idea comes, he should work it out with care and present it to the manager along with his copies of recommendations he has previously handed the chief. If the operator has backbone, he can sell his plan to the manager, using as a pretext for the direct approach, the chief's refusal to use former ideas. If the operator fails in his argument, then he is free to hunt another job.

Nohting will keep a chief so receptive as the belief that the operator may go over his head. Some may say that the program I am recommending will destroy the morale of the force. Temporarily, this may happen, but if the chief is right, the operator is soon out of a job and if the operator is right, a new chief will soon be

running things. Of course this plan is contrary to the army method of sending ideas "through the proper channel," but one must remember that the army plan was evolved by a lot of officers who wanted no first sergeant to show them up. Without the army plan a lot of generals would probably be doing K.P. work and some first sergeants would be wearing gold stars.

If you have faith in an idea, never let a mistaken sense of loyalty to a chief prevent your reaching success.

Newark, N. J. JOHN MORIARITY.

THE manager is a busy man and generally is able to size up things. He must and will consider the position the chief holds; should he listen to a subordinate and decide that he is right, there will be no further use for a chief.

The manager would be everlastingly pestered with subordinates from all departments with ideas and axes to grind. The morale of the plant would soon be lost. Ideas are fine, but to keep up the morale of the plant they must come through the correct channels. R. CATER.

Westville, N. J.

Remote Control of Unit Heaters

IN THE Atlanta, Ga., public schools, ventilating and heating units are installed in each room. It was desired to start or to stop each unit by individual push button, or to start them all at once by pressing a master push-botton station. All motors were to be stopped simultaneously by opening a line switch at the power panel of the main switchboard.

The two combinations of control, Fig. 1 and 2, were worked out by H. J. C. Pearson, consulting engineer, in collaboration with the General Electric Company. The control involves a push-button station and a relay. With the arrangement Fig. 1, the relays *B* are normally energized and their contacts are held open. The individual motors are started by closing push buttons *A*, which completes the circuit for the coil on contactor *D*.

Pushing button *C* down opens its top contacts and closes the bottom ones. This operation opens the *B* relay-

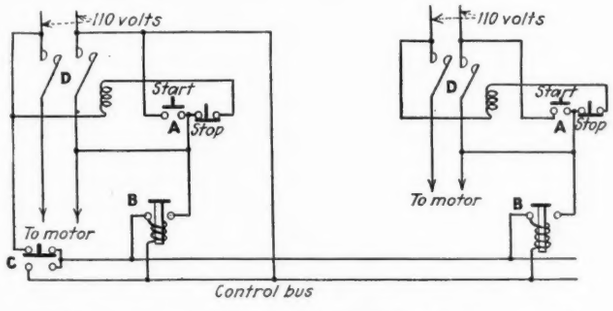


Fig. 1.—Connection diagram with relays held open by their coils

coil circuits and they close their contacts, which close the *D* contactor coils' circuits through the bottom contacts of button *C*. Completing these circuits will start all the motors as a unit. Any unit may be stopped without affecting the others.

In Fig. 1 the relay coils are across the line at all times except momentarily, when the motors are started. There will be about 2,000 of these relays with a power consumption of four watts each, which would amount to 8,000 watts. The relays have been modified, as in Fig. 2, by reversing the contacts, making them close the auxiliary circuits when voltage is applied, instead of opening it, as in Fig. 1. This arrangement eliminates the power consumption required to hold the relay open,

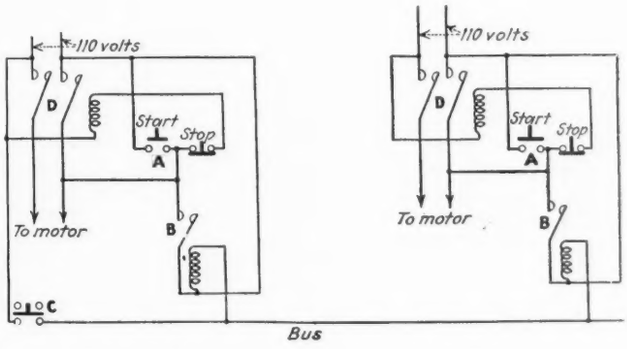


Fig. 2.—Connection diagram with relays normally open and are closed by their coils

as in Fig. 1. In Fig. 2 the relay coils are energized only for the brief interval that push button *C* is pressed.

Atlanta, Ga. A. M. HILL,
General Electric Company.

Flooding a Barometric Condenser

IN THE Feb. 12 number G. W. Clarke relates some difficulties he has experienced with water collecting in the exhaust pipe of an engine where it ran under the floor and then connected with the uptake pipe of the condenser.

I had a similar experience while operating a couple of steam turbines. The exhaust pipe was 20 in. in diameter and we never had any trouble at loads above 50 per cent of capacity, but sometimes on Sundays, when one of the turbines was running alone at about one-fourth load, the exhaust pipe would be almost cold back to the turbine and naturally some water would accumulate. It was our practice to wait until a slight knocking showed that enough water had accumulated to cut down the area of the pipe, and then we would open a valve to break the vacuum and shut off the injection water to the condenser.

As soon as the vacuum was lost, two 2-in. swing check valves on the bottom of the pipe would automatically open and allow the water to run out. We would have to do this every two hours during the day until the load increased considerably toward evening. At a time previous to this the water had accumulated to such an extent that it surged back into the turbine and a number of blades were torn out.

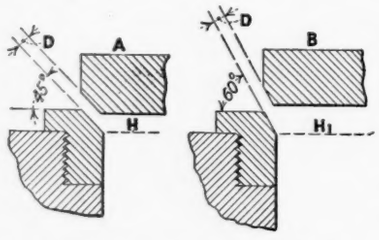
The arrangement shown by Mr. Clarke for taking care of the condensation without breaking the vacuum is undoubtedly practical, but I think a good type of vacuum trap would be more satisfactory. Usually, such a trap is one that uses a tilting receiver and has a live steam connection. While accumulating the water, the steam connection and the discharge are closed, then when the trap tilts the connection to the exhaust line is closed, steam is admitted and the water discharged through the outlet to the boiler or receiver.

Cambridge, Mass. G. H. KIMBALL.

Why Some Relief Valves Are Noisy

RELIEF valves have a habit of vibrating and causing considerable noise when they open. The vibration is generally both axial and lateral and is due to varying pressure of the liquid passing through the valve and to uneven velocity flow between the disk and seat. Noisy discharge of relief valves may be caused also by the angle of the seat, as in the following case:

A 2½-in. relief valve on a benzine pressure line leaked. Our machine shop reseated it. When it came back it was noticed that the 60-deg. angle of the seat had been changed to 45 deg. The valve was installed, but when it opened the noise it made was terrific. It was returned to the shop to have the original 60-deg. seat angle restored. After this was done the valve discharged quietly. The lift of these valves ordinarily, when discharging, is small. The illustration shows portions of two valve disks *A* and *B* and their seats. The disk *A* has a 45-deg. angle and the disk *B* a 60-deg. angle. They have been raised the same amount off their seats measured at right angles, but disk *B* has been raised considerably higher vertically than disk *A* as shown by *H* and H_1. From this it is apparent that with the same discharge opening and the same amplitude of vibration, the disk *A* will hammer its seat, while *B* will not. Also, the greater the angle of the seat joint the higher the disk will rise for a given discharge.



Comparison of vertical lift with efficient face angles

W. L. PARKER.

Elgin, Ill.

Why Scrape a Bearing to Fit?

IN RECENT numbers of *Power* comments have appeared on scraping bearings to fit, and I cannot agree with the writers who oppose this method of finishing bearings. One writer says he has babbitted up bearings on engines rated as high as 1,000 hp. and run them in without scraping and got by with it, but he does not tell us how much trouble he had afterward or how frequently the bearing had to be adjusted.

Another writer refers to a railroad car journal brass. Even these have to be fitted and will give better and longer service if scraped or filed to a fit. Scraping a bearing or moving part of an engine or machine has its place and is, in my opinion, the only method of doing good and accurate work.

Crankpin brasses that have been bored out on a lathe or boring mill have a certain amount of error, and unless they are scraped or filed to a fit, they require frequent adjustment to get them to run satisfactorily. If they run cool, there is always a feeling of doubt about their continuous performance.

The method suggested by C. J. Mason in his letter in the Jan. 8 issue with regard to "planing the valve seats in one direction and the faces of the valve in a right-angle direction," does not eliminate the error caused by the springing of the face of the valve or cutting tool, or by the springing of the work due to improper clamping on the machine. This also applies to the rotating bearings or parts that are machined on lathes or boring mills. This is where the high-class mechanic recognizes the error and uses good workmanship and finishes his work up to a standard by spotting and scraping to a running fit.

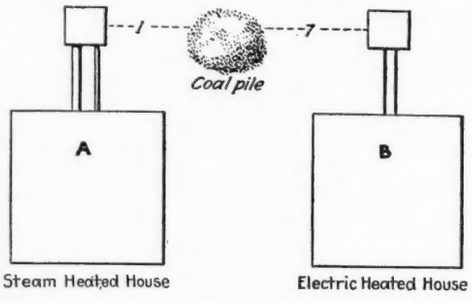
Washington, D. C. H. P. ROBBINS.

House Heating by Electricity

I HAVE always been interested in house heating by electricity and so read with interest the short article on page 240 of the Feb. 5 issue on that subject. Figuring anthracite as we know it in Pennsylvania, 2,240 lb. per ton and 13,500 B.t.u. per lb., I calculate the cost per ton would have to be $37.62 to equal electricity at 0.425c. per kw.-hr. on the basis of the same B.t.u. delivered in both cases.

As to house heating with electricity derived from coal: Build two identical houses and heat both to the same extent, one with electricity, the other with steam. In each case keep the heating plants outside the houses. That is, build the little steam plant *A* and the little electric plant *B* outside of the respective houses. *A* will be connected to its house by a steam pipe and a small return pipe. *B* will be connected to its house with two wires. In each case a little loss results in transmission, but very little — call the one equal to the other.

In *A* 80 per cent of the heat in the coal may be made to come out of the nozzle of the boiler and enter its house for heating. In *B* there must be a turbine or an engine in addition to the boiler. Again, 80 per cent of the heat in the coal may be made to come out of the nozzle of the boiler and enter the heat engine driving the electric generator. From the generator 15 per cent of the heat furnished the engine may be expected in the form of electricity for delivery to its house for heating. Thus there arrives at the electrically heated house 15 per cent of 80 per cent, or 12 per cent of the heat in the coal fired. House *A* gets 80 per cent of the heat in any unit of coal. House *B* gets 12 per cent of the heat in any unit of coal. House *B* therefore consumes practically seven times as much coal as house *A*. Consequently, when electricity must be derived from coal by the route of the heat engine, which is the only route we know, we cannot afford to use it for house-heating because it consumes approximately seven times as much coal as is necessary by other methods.



Diagrammatic layout of houses and heating plants

This analysis of house heating by electricity is given to all engineering students at Lehigh University. Does any one consider it unsound?

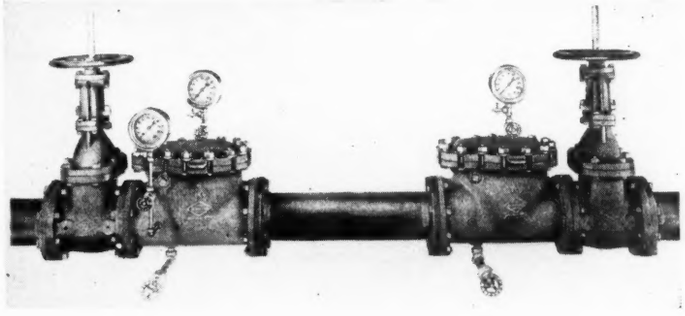
Bethlehem, Pa. F. V. LARKIN,
Department of Mechanical Engineering,
Lehigh University

What's New in Plant Equipment

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING TRANSMITTING AND APPLYING THE POWER SERVICES

Valve Assembly for Fire Protection Systems

TO PROVIDE additional protection where domestic water supply is used as the primary supply for automatic sprinklers and other fire protective apparatus, and water from rivers or open ponds is pumped into the same system in the event of fire, Jenkins Bros., 80 White St., New York City, have brought out the valve assembly illustrated.



Gate- and Check-Valve Assembly Used as Cross-Connection Between Public Mains and Secondary Water Supply

This assembly is installed as the connection between the public mains and the high-pressure fire system of the building or plant. When the high pressure is built up, the check valves automatically close and protect the domestic supply from pollution and prevent the loss of water back through the public mains. As will be apparent from the illustration, two (all-bronze) check valves are installed between two gate valves with a spacer (3 to 5 ft. long) between the check valves. The check valves may be bolted together if desired, but the use of the spacers precludes the possibility of any ordinary material which might get into the pipe from holding both clappers open at the same time.

To permit the ready checking of the valves for tightness, each is equipped with a gage on either side of the clapper and with a drain on the low-pressure side of the clapper. The disk holder of each valve is fitted with a special rubber facing or disk to insure tightness. The gate valves have bronze-bushed stuffing boxes, bronze stuffing-box nuts and bronze packing glands.

It is pointed out by the manufacturer that the valves used in this assembly are approved by the National Board of Fire Underwriters and Associated Factory Mutual Insurance Companies, and are suitable for water-working pressures up to 150 pounds.

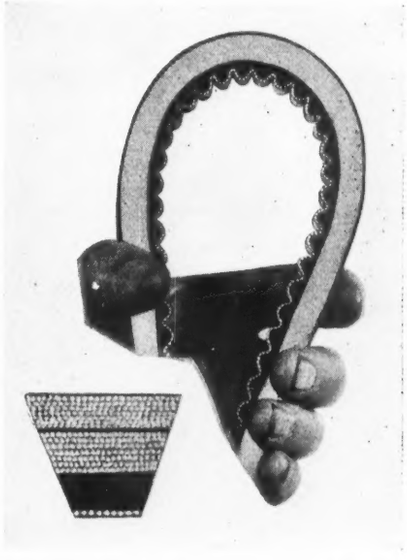
Flexibility a Feature of V-Shaped Belt

FOR short-center drives V-shaped belts running in grooved pulleys have come into extensive use. A belt of this type having special features has been placed on the market by the Dayton Rubber Manufacturing Company, Dayton, Ohio. This belt is trapezoidal in cross-section and has a series of tooth-shaped corrugations on its inner surface, shown in the figure, from which it derives its name, Cog-belt. The cogged surface is not for the transmission of power, but provides flexibility and prevents buckling when the belt is flexed around the pulley.

As shown in the figure, the cross-section of the belt includes three zones—the outer, or tension, the inner, or compression, and between these two the neutral zone. When a belt flexes around a pulley the outer portion is under tension. This section has been made so that it can elongate without undue internal strain. It consists of a series of convolute layers of a bias-cut fabric providing the right amount of give. Since the belt is die cut, the ends of the threads in these layers are exposed to the sides of the pulley grooves to form part of the driving surface. Since the fabric is cut on the bias, it cannot ravel and provides tough riding surface with a high coefficient of friction.

The strength member of the belt is in the neutral zone. The section consists of a series of convolute layers of prestitched parallel-cord fabric. When the belt is being made, the cords are put under heavy tension and permanently set in this position by vulcanizing. This construction is to give the belt non-stretching qualities.

To obtain flexibility without distortion, the compression section of the belt is made of rubber and fabric and is corrugated. This construction gives the belt a tendency to hug rather than resist the pulley arc. In the cogs the fibers are run crosswise, creating cross-sectional rigidity to prevent distortion. The construction is such that the riding surface of the belt is a continuation of the ends of threads in the fabric on the bias, edges of cord cables and end of fibers in the



Lower left—Cross section of belt. Right—Cogged surface allows the belt to bend easily

teeth, all of which have a certain portion of rubber.

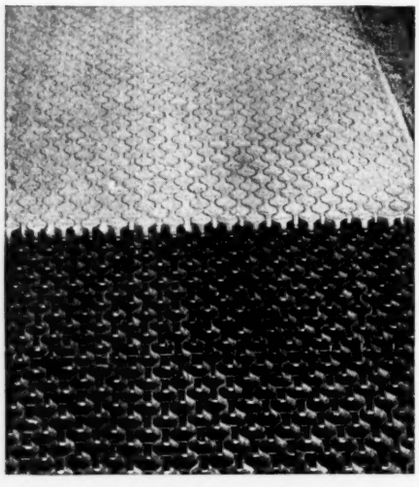
These belts can be used for almost any application where a short-center drive is required, such as fans, pumps, compressors, conveyors, cement mills, paper mills, etc.

Steel Armoring for Concrete Floors

A MATERIAL for steel-armoring concrete, asphalt and composition floors, designed to give a surface as strong as any part of the floor and thus increase the useful life of the floor, is a recent development of the Blaw-Knox Company, Pittsburgh, Pa.

The material, which is known as "Floorgard," is a built-up continuous steel mat that is laid down to form the surface of the floor. The design of the armoring is such that stresses are taken care of by the steel itself and the loads distributed throughout a wide area of floor. In addition, the design is such that that portion of the concrete appearing between the steel bars is in no way divided into separate portions, but is "monolithic" with the rest of the concrete forming the floor body.

The armoring consists of a number of steel strips, shaped into a regular



Filled and unfilled sections of steel-armored floor

pattern, which, when placed together, form a series of separate rectangles of proper size to meet the conditions under which a given floor must work. The strips are set on edge, as shown in the illustration. Small, short circular tierods are inserted in a horizontal position, through holes in the middle of the strips. These tierods act as carrying members, tying one strip to another, as well as tying the entire surface into one steel mat. The construction is of such a nature that it can be formed to meet practically any possible floor requirement.

Small steel lugs between adjacent strips at the points where the tierods go through, act as anchors to keep the steel strips in the plastic material, and also as separators between the strips, avoiding any possibility of rust due to contact of steel. There are no acute angles to cause the formation of thin, easily broken fins of concrete. In installations where it is not necessary to protect the entire area of the floor, the armoring can be laid in places and at points where wear is the heaviest. It also can be easily cut in the field to fit around machine bases, columns or other obstructions.

"Floorgard" is made in various sizes of mesh to conform with varying conditions, such as weights of loads, types of traffic, etc.

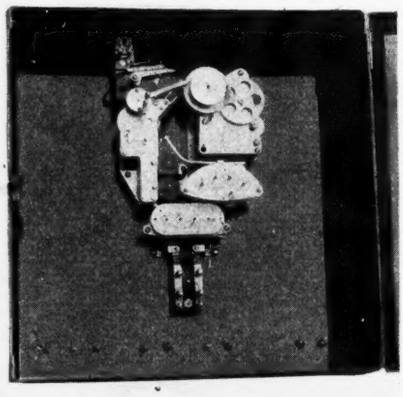
Maximum Demand Controlled Automatically

WHERE power is purchased and there is a demand charge in the rate, it is frequently possible to realize material reductions in the monthly power costs by reducing the maximum demand. To control the maximum demand automatically, the Steelcity Furnace Company, Pittsburgh, Pa., has developed a device, known as a "Limuter," shown in the figure. This equipment is for automatically cutting off or reducing the power load, where the plant machinery will permit, to a predetermined value whenever the load tends to increase the demand above a desired maximum.

The demand period of the "Limuter" may be set to correspond to the demand period of the power company's meter, such as 5, 15, 30 or 60 minutes. The demand limiter, being maintained in synchronism with the demand meter, allows full power load up to the time that the demand for the period is about to be exceeded, and then reduces the load to the desired amount.

The mechanism of the demand limiter is operated by a synchronous timing motor or a self-winding clock, similar to that in the demand meter. There are a number of ways that the device may be arranged to reduce the load, such as on an air compressor, by increasing the clearance with solenoid operated valves; on a pump or blower, by reducing the speed or shutting the equipment down temporarily; and shutting other machines down that cause the demand to be exceeded and restarting them again after the demand period is passed.

The load is controlled on an integrated peak basis. At the beginning of a demand period any quantity of power can be used without causing the controlled equipment, such as motors, to be interrupted. A register



Demand limiting device with the cover removed

is used to show the number of times the device operates to reduce the load. This acts as a check against interruption from other causes. There is also a totalizing register on the demand limiter, which serves as a check on the watt-hour meter.

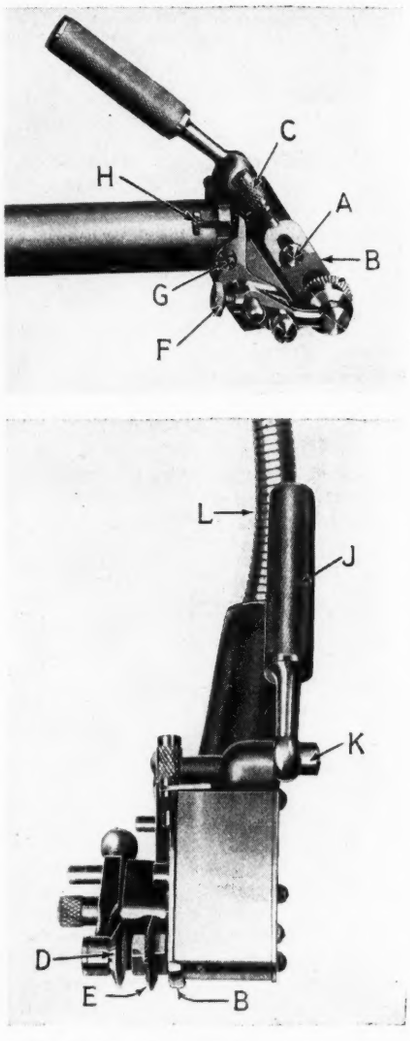
High-Strength Bronze Welding Rod

AN IMPROVED bronze welding rod, designated Oxweld No. 21, is announced by the Oxweld Acetylene Company, 30 East 42nd St., New York City. This rod is recommended for all bronze welding applications, including the fusion welding of brass and bronze, bronze-welding of malleable and gray-iron castings, joining dissimilar metals and building up bearing and other wearing surfaces. Due to its composition it has a uniformly low melting point and easily controlled flow. It is said to produce a weld metal as hard and wear-resistant as that formerly made with manganese-bronze rod, and to give a tough and ductile weld metal having a tenside strength of over 45,000 lb. per sq.in. In addition, it will make a stronger bond with ferrous metals.

Properties of the rod eliminate almost all boiling and fuming of the weld metal. Annoying fumes are reduced to a minimum and elimination of oxide and gas inclusions tends to give a sound and strong weld with better adhesion to iron and steel.

Improved Mica Undercutter

THE improved ("Ideal," model 1929) commutator mica undercutter illustrated can be operated in a space 3½ in. wide or in most cases without dismantling brushes, brush boxes or brush rigging. Other advantages claimed for the device are that it will not heat, jump or chatter.



Ideal (model 1929) commutator mica undercutter

Referring to the illustration, *A* is a setscrew locking the adjustable depth gage *B*, and *C* is a micrometer adjusting screw for raising and lowering it. A micrometer adjusting screw is also used for setting the roller guide *D* the proper distance from the cutter *E*. The distance between the cutter and roller can be adjusted to the width of the average small copper bar, thus permitting the guide to be used on the second slot after cutting the first slot by hand. Setscrew *F* locks the roller guide in position, and screw *G* permits the entire roller guide assembly to be rotated so as to permit easy replacement of the cutters. Also, adjusting screw *H* permits raising or lowering the roller guide to conform to the size or diameter of cutter used. Two locknuts hold the cutter in place on the shaft.

Right next to the saw is the depth gage *B*, placed so that the depth can be measured instantly. It is made with a wide surface so that it will not mar the commutator. An extra swivel handle *J* is provided for convenience in holding. This handle can be set at any position by the locknut *K*. Power to drive the cutter is provided through the flexible shaft *L*, which is direct connected to a motor.

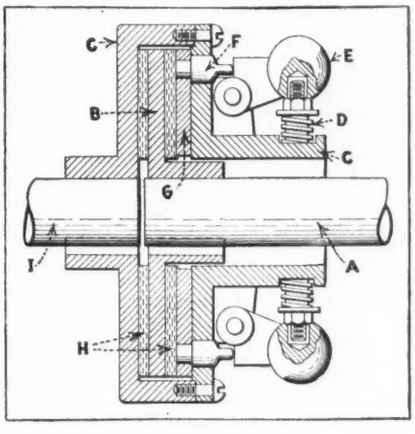
Accelerating Clutch for Direct, Chain and Belt Drives

THE illustration shows an accelerating type of clutch designed for installation between a motor and a driven machine to reduce the starting torque and permit the machine to start with a uniform acceleration. Its use relieves both the machine and the motor of undue shock and strain, and it requires a less expensive type of electrical control.

The clutch is automatic in action and requires no lubrication. It may be mounted as a coupling between the motor and the machine or may be driven by a belt or chain from the motor. It will operate in either a horizontal or a vertical position and is applicable to any constant-speed alternating or direct-current motor. The time of the acceleration varies between 15 to 45 sec., and no wear occurs when running at full speed, thus insuring long life to the friction surfaces.

The clutch operates on a similar principle to the ordinary disk clutch except that the cam action, instead of being operated by hand, is controlled by centrifugal force, which causes it to engage automatically. The illustration shows a cross-section of a direct drive. To the motor shaft *A* is keyed the disk *B*. When the current is applied to the motor, the only load on the motor is a slight pressure of the friction *H* on the sides of the disk *B*. This pressure is so slight that the motor comes to speed in the usual length of time and is controlled by the spring *D* through the bell crank *E* to the pin *F* fastened to the pusher plate *G*. With the motor at full speed and with the slight spring pressure, a slip takes place between the friction *H* and the disk *B*, tending to set in motion the head *C*, which is keyed to the output shaft *I*. When the head *C* reaches a speed sufficient for centrifugal action to take place in the bell crank *E*, the pressure on the pusher plate *G*, friction *H* and disk *B* is increased, resulting in increasing the speed of the head *C*, which, in turn, increases the centrifugal action, with resulting increase of speed. This cycle continues until the speed of the head *C* is equal to the speed of disk *B*, or the same as the motor speed.

This principle permits a wide range in design for different purposes. The weights can be designed to apply sufficient force to make the clutch practically a solid coupling at full speed or, if desired, they may be of a weight that will disconnect the clutch entirely at any desired percentage of overload and allow the motor to run freely. The clutch has been developed by the Washburn Shops of the Worcester Polytechnic Institute, Worcester, Mass.



Cross-section of accelerating clutch used for direct drive

New Slot Insulation Paper

A SMOOTH, tough, flexible fiber paper (No. 1850) of high mechanical and dielectric strength particularly suitable for use as a slot insulation is announced by the General Electric Laboratories, Bridgeport, Conn. This material combines such qualities as resistance to folding, high tearing strength, high tensile strength and high dielectric value. The paper is also furnished as follows: Treated with an insulating varnish, and designated No. 1851; treated with an insulating oil, and known as No. 1852.

FROM AMONG THE READERS'

Conducted
By
L. H. Morrison

Detecting CO_2 Leaks.—*I am operating a carbon dioxide compression refrigerating machine and find that the system is losing 50 lb. of CO_2 each day. How can the leaks be detected?* C. F. R.

Add peppermint oil to the system and the pronounced smell of this oil will be in evidence around the leak. If the CO_2 coils are in a brine tank the brine should be removed so that the peppermint smell will reveal any leaks in the coils.

Power Transmission for Difference in Belt Tension.—*What would be the difference in tension on the tight and loose sides of a belt traveling 1,200 ft. per min. to transmit 6 horsepower. What number of horsepower would be transmitted with the same difference in tension for a belt speed of 400 ft. per min.?* M.D.

Transmission of 6 hp., or $6 \times 33{,}000 = 198{,}000$ ft.-lb. per min., at a speed of 1,200 ft. per min. would require a difference of tension of $198{,}000 \div 1{,}200 = 165$ lb., and a belt speed of 400 ft. per min., with the same difference of tension, would transmit $\frac{400}{1{,}200}$ of 6, or 2 horsepower.

Measuring Three-Phase Power with Two Single-Phase Wattmeters.—*Two single-phase watt-hour meters are used to measure the energy of a three-wire three-phase load which operates a considerable part of the time at power factors below 50 per cent. It is well known that when the power factor is below 50 per cent, one of the meters runs backward. How would the monthly power consumption be determined from these meters?* H.M.

Two single-phase watt-hour meters connected to measure the total load on a balanced three-phase system will show the same readings at unity power factor load only. At power factors less than unity, for a given load, the reading of one meter increases and the other decreases at the same rate. Therefore, the sum of the two readings is the correct power consumption.

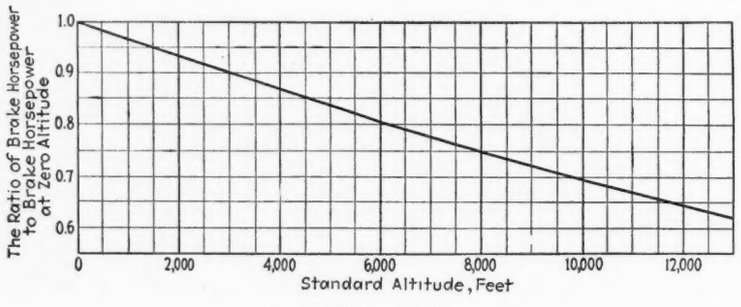
When the power factor is less than 50 per cent, one meter will reverse and subtract from the total registration on this meter. If for one month the negative exceeded the positive registration, the total registration on this meter would be less than shown the previous month. The amount of this decrease is subtracted from the other meter's reading to obtain the power consumption. This is an unusual condition and one that should suggest taking immediate action to correct the power factor.

Colored Gasoline.—*Why do refiners give anti-knock gasoline a green, pink or other distinctive color? Is the gasoline naturally of this color?* J.C.B.

Much of the anti-knock gasoline is nothing but gasoline produced by a cracking process. This gasoline coming from the still has a muddy color and a coloring is added to give it a more pleasing and valuable appearance.

Effect of Altitude on Output of a Gas Engine.—*What can one reasonably expect in power output from a gas engine located at an altitude of 8,000 ft, if the sea-level rating is 500 hp.?* G.B.S.

The curve in the accompanying chart shows the usual deductions in rating at various altitudes. For example, at 8,000 ft. the engine will deliver 75 per cent of its sea-level rating. This assumes a constant mechanical friction loss and a pumping loss in accordance with the air density.



Loss of Capacity with Altitude

Engine Piston Leakage.—*Will a piston leak steam when traveling even though it may seem to be right when blocked and tried; and could there be such a thing as leakage past the rings when changing the direction of travel at the ends of the stroke due to side play of the rings?* H.L.K.

It is practically impossible to prevent all piston leakage. The wear of the cylinder is not uniform for the full length of the stroke, and testing the tightness of the piston at one point does not demonstrate its tightness at other points along the stroke. Leakage may be introduced by side slippage of the rings from reversal of the stroke, but this, like leakage shown by blocking the piston at any point, may be only momentary, while the piston is traveling over that particular point, and it should not be taken for granted that the degree of tightness or rate of leakage found with the piston blocked is the rate of leakage during regular operation. The leakage when running will be considerably less than the highest rate of leakage observed with the piston blocked at a point that shows the most leakage.

Horsepower of Pump.—*What is meant by the horsepower of a pump?* H.P.R.

Five different values of horsepower of a pump must be distinguished: (1) The indicated horsepower of the steam end, obtained from indicator diagrams of the steam end in the same way as determining the indicated power of a reciprocating engine; (2) the brake horsepower, or power actually transmitted to the pump, and which in a direct-acting steam pump would consist of the indicated power of the steam end less the friction of parts essential to operation of the steam end; (3) the indicated horsepower of the water end, obtained from indicator diagrams taken from the water cylinder to determine the power transmitted by the water piston or plunger; (4) the water, or developed, horsepower to express the useful work done by the pump, based on the actual weight of water discharged and total height through which the water is elevated; (5) what is commonly recognized as the nominal horsepower, which is based on the weight of water that would be displaced per minute by the plunger or piston if there were no slippage, combined with the discharge pressure plus the lift measured from the water level in the suction well to the height of the discharge gage. Thus, if the plunger or piston displacement is 1,000 gal. per min., it would be assumed that the pump actually handled $1{,}000 \times 8\frac{1}{3} = 8{,}333$ lb. of water per minute; and if the discharge pressure indicated 40 lb. per sq.in. and the height of the gage was 16 ft. above the water level of the suction gage, the total lift would be considered as equivalent to $(40 \text{ lb.} \times 2.3 \text{ ft. per lb.}) + 16 \text{ ft.} = 108$ ft., making $8{,}333 \times 108 \div 33{,}000 = 27.27$ nominal pump horsepower.

PROBLEMS

OPERATION OF TURBINE GOVERNOR.—*With a hydraulic turbine governor, will the governor remain in the same position as long as speed of the turbine is the same, or do the governor weights stand at different positions for different loads on the turbine?* C.S.R.

When a turbine is governed by the indirect, or what is commonly called the "relay" method, the centrifugal force of the governor is needed only to "give the signal," which sets in motion an auxiliary mechanism by which the valves are moved by gearing connected to the mainshaft or by steam or by hydraulic pressure. The signal is given for more or for less speed, according to requirements, and continues until the correct speed is satisfied. There is the same speed and therefore the same standing of the governor weights when the speed is satisfied with one load as with another, within the range of variation required for operation of the pilot valve.

DOES IT PAY TO CORRECT THE POWER FACTOR?—*We have a 450-hp. synchronous motor driving a 300-kw. direct-current generator. To raise the power factor from 0.85 to 0.95 lagging, the motor's exciting current was increased five amperes. This caused an increase of 25 amperes in the motor's stator current. What caused the increase in the stator current? Power is purchased on a rate that gives a discount for good power factor. Does it pay to overexcite the motor to improve the power factor?* E.C.M.

Increasing the field current of the synchronous motor caused its power factor to decrease, leading. So far as the motor is concerned, its stator current for a given load will increase if the power factor decreases leading, just as it will if the power factor decreases lagging.

The meter is connected to show the power factor of the system and not the motor, consequently it does not show the motor's power factor. If there were an ammeter connected to measure the total current taken by the power system of the plant, it might be found that when the synchronous motor's current increased, the system current decreased. This for the reason the power factor of the system had been improved. It might also be found that the system current increased.

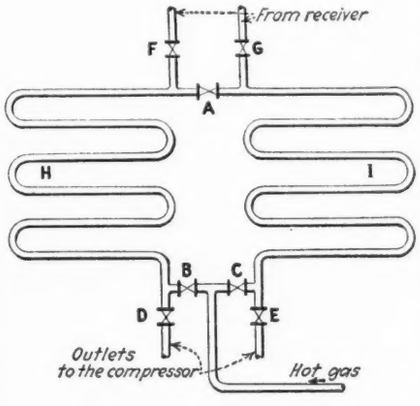
Whether it pays to correct the power factor of the system from 0.85 to 0.95 will depend on the amount of discount obtained in the power rate and on how the load is distributed on the power system. If the synchronous motor is on a separate feeder, it only corrects the power factor at the busbars. Under such conditions the increased losses in the synchronous motor and the line, caused by the motor's leading power factor are not in any way compensated for. For this reason the power consumpton to supply a given load on the system would be increased.

If the synchronous motor is on a feeder with induction motors, it will correct the power factor of the feeder and decrease the current to be transmitted for a given load. This will reduce the losses in the feeder, but how much will depend upon load condition. If the feeder loss decrease is greater than the motor loss increase, then the total power consumption will decrease. The foregoing gives an idea of what must be considered in the problem. Ordinarily, it does not pay to provide means to correct the power factor above 85 or 90 per cent.

DEFROSTING COILS.—*In our storage room we have two sets of direct expansion ammonia coils. How can we arrange to defrost these coils by using hot gas?* G.C.S.

The illustration shows diagrammatically how the coils can be connected to allow hot gas to enter from the compressor.

The usual expansion valves are at *F* and *G*. If there is not a cross-connection, one should be established at *A*. The outlets to the compressor should be provided with valves *D* and *E* and a hot-gas line run as shown, with stop valves at *B* and *C*. To defrost the coil *H*, the valves *F* and *D* are closed, and *B* is opened. The hot gas enters through *B* and, with the valve *A* closed, is condensed in *H* and in so doing heats the frost on the coil *H*. A pressure of, say, 50 lb. will be established in *H*, and if the valve *A* is now opened, the liquid ammonia in *H* will flow into coil *I* and evaporating at the existing pressure, will perform a refrigerating duty just as if it came from the receiver. The cold gas leaves through the valve *E* on its way to the compressor.



Defrosting arrangement

HORSEPOWER TO PUMP WATER.—*What horsepower is required to pump 500 gal. of water per minute against a total pressure of 100 lb. gage, allowing 15 per cent slippage in the pump?* C.F.G.

The work done per minute is the product of the weight of water and the height to which it is lifted. Stating this as a formula, work per min. ft.-lb. $= WH$. The total weight lifted is $500 \times 8.33 = 4{,}165$ lb., 8.33 being the weight of one gallon of water. The equivalent head in feet is 100×2.3, as a column of water 2.3 ft. high will exert a pressure of one pound per square inch. As a horsepower is the rate of doing work of 33,000 ft.-lb. per minute, we have

$$\text{Hp.} = \frac{WH}{33{,}000} = \frac{4{,}165 \times 100 \times 2.3}{33{,}000}$$

$= 29$ hp. But to take care of the slippage, we must add 15 per cent, making the total horsepower 33.3.

ADVANTAGES OF STEAM JACKETING.—*It is claimed that steam jacketing reduces the cylinder condensation of an engine by raising the mean temperature of the iron walls. If the mean temperature is raised, why is the heat loss to the exhaust not increased by reason of the greater temperature difference between the cylinder wall and the steam during the exhaust period?* L.S.M.

Jacketing does raise the mean temperature of the cylinder walls, but it has been found that the coefficient of heat transfer during the later part of the expansion stroke and during the exhaust stroke is less than during the admission period, on account of the existence of a film of condensed steam. Consequently, the higher mean wall temperature reduces the heat transfer during the admission period without increasing it during the exhaust period, over the transfer in an unjacketed engine.

A Question For Our Readers

WE HAVE purchased a 400-hp. four-stroke-cycle Diesel and intend to install it in a plant in Denver, Colo. We are told that the engine will not develop its rating on account of the altitude. Is this true, and if so can we do anything to bring its capacity up to its sea level rating? G. S. C.

Suitable answers from readers will be paid for and published in the April 2 issue

High Efficiency Is Obtained
With the Hult Gas Engine

By JOHN A. DENT
Professor of Mechanical Engineering, University of Pittsburgh

THERE is a general impression that for a given final compression pressure, the Otto gas engine gives the highest efficiency of any workable cycle. That this is far from true can be proved by a study of the Hult cycle described in the Dec. 18, 1928, issue of *Power*. The construction of the engine is outlined in Fig. 1. Briefly, an air pump forces the air change into a set of cooling tubes, where it is cooled to intake temperature. On the next pump stroke this air re-expands to below atmosphereic temperature and pressure. On the third stroke it is forced into the working cylinder along with the fuel; here it is ignited and expands until exhaust takes place.

Assume for the Otto cycle engine a suction air temperature of 80 deg. F., a compression ratio of 4 to 1 and a temperature rise at ignition of 3,000 deg. F. The final compression temperature will then be 480 deg. F., or 940 deg. F. absolute, and the maximum explosion temperature will be 3,940 deg. F. absolute. The efficiency will be 42.6 per cent; this is calculated from the formula

$$E = 1 - \frac{1}{(r)^{n-1}}, \text{ or}$$

$$E = 1 - \frac{1}{(4)^{0.41}} = 42.6 \text{ per cent.}$$

For the Hult cycle the same intake temperature of 80 deg. F. is assumed.

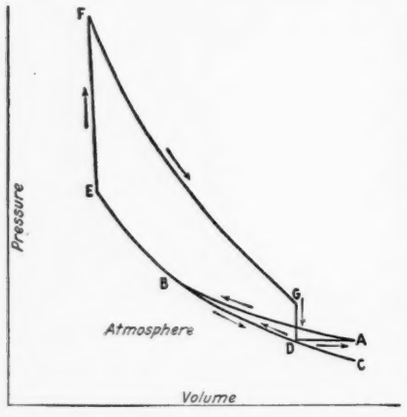


Fig. 2—A theoretical indicator diagram of the Hult engine

The compression ratio in the compressor cylinder is taken as 2 to 1; the compression end temperature of the working cylinder is taken as 480 deg. F. with the explosion temperature of 3,940 deg. F., as in the Otto cycle.

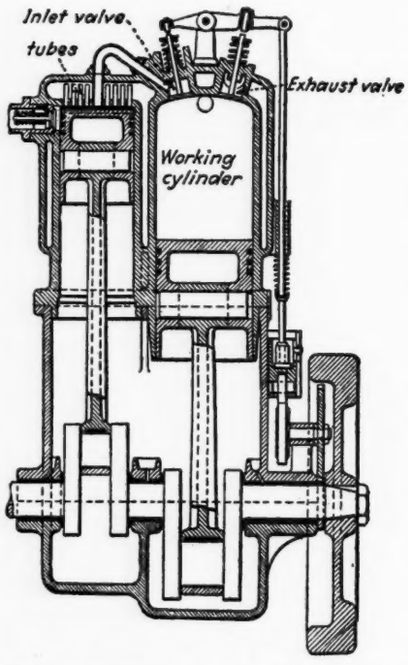


Fig. 1—Cross-section of the Hult engine

An indicator diagram, showing the pressure volume changes in the compressor and the working cylinder, is shown in Fig. 2, while the temperature-entropy changes are outlined in Fig. 3.

The line *AB* depicts the changes during compression in the compressor cylinder. Owing to the cooling tubes this compression is theoretically isothermal. Re-expansion in this cylinder is represented by the line *BC*, which is an adiabatic, and *CD* covers the recompression stroke in the same cylinder, which is also assumed to be adiabatic.

At *D* the air is transferred without change of state to the working cylinder, and adiabatic compression in this cylinder is covered by the line *DE*. Combustion occurs from *E* to *F* at constant volume, folowed by adiabatic expansion along the line *FG*, after which the burnt gases are expelled from the cylinder at constant volume, as shown by the line *GD*. This is followed by a return to the initial condition along the line *DA*.

Note that the portion *CD* of the compression *CE* takes place in both cylinders, but for the purposes of analyses this division can be ignored.

The efficiency of the Hult, as of all cycles, is $\frac{Q_1 - Q_2}{Q_1}$ where Q_1 is the heat added and Q_2 is the heat removed per cycle.

If we let C_v be specific heat at constant volume and C_p the specific heat at constant pressure, we have $K = \frac{C_p}{C_v} = 1.4$

For convenience W the weight of charge per cycle can be so chosen that $WC_v = 1$.

Then $Q_1 = WC_v\ (T_F - T_E) = 3{,}000$ B.t.u. The heat removed Q_2 consists of the heat removed from A to B, which is $WC_v\ (K-1)\ T_A \log_e \frac{V_A}{V_B} = 1 \times 0.4 \times 540 \times 0.693 = 150$ B.t.u., and the heat removed from G to $D = WC_v\ (T_G - T_D)$. Since $T_D = T_B \left(\frac{P_D}{P_B}\right)^{\frac{k-1}{k}}$ we can write this $T_D = 540 \left(\frac{1}{2}\right)^{\frac{.4}{1.4}} =$ 433 deg. abs. and as $\frac{T_G}{T_F} = \frac{T_D}{T_E}$, $T_G =$ $3{,}940 \left(\frac{433}{940}\right) = 1{,}814$ deg. F. abs.

Therefore the heat removed from G to D is $1(1{,}814 - 433) = 1{,}381$ B.t.u. and the heat added from D to A is $WC_p\ (T_A - T_D) = KWC_v\ (T_A - T_D) =$ $1.4 \times 107 = 150$ B.t.u. The net heat removed Q_2 is $150 + 1{,}381 - 150 =$ 1,381 B.t.u.

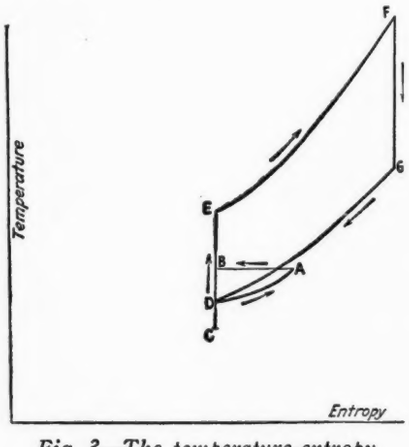


Fig. 3—The temperature-entropy diagram

The efficiency is then $\frac{3{,}000 - 1{,}381}{3{,}000}$ = 54 per cent. As compared with the 42.6 per cent of the Otto cycle, the gain over the latter is approximately 27 per cent.

However, in practice the compression AB will not be truly isothermal nor will the expansion BD be adiabatic. Assume AB to be represented by the equation $PV^{1.1} = C$ instead of $PV = C$ and that the line BD conforms to the equation $PV^{1.35} = C$. Keeping the other data as in the theoretical cycle, we have: $T_B = 540(2)^{0.1} = 579$ deg. F. abs.; $\frac{B_B}{P_A} = (2)^{1.1} = 2.153$; $T_D = 579\left(\frac{1}{2.153}\right)^{\frac{35}{1.35}} = 474$ deg. abs. and $T_G = 3{,}940\left(\frac{474}{940}\right) = 1{,}988$ deg. abs. As before, we will assume Q_1 to be 3,000 B.t.u.

The heat removed from A to B is $\left(\frac{1.4-1.1}{1.1-1.0}\right) WC_v(T_B - T_A) = 3 \times 39 = 117$ B.t.u.

The heat added from B to D is $\frac{1.4-1.35}{1.35-1.0} WC_v(T_B - T_D) = 15$ B.t.u.

The heat removed from G to $D = WC_v(T_G - T_D) = 1{,}514$. The heat added from D to $A = WC_p(T_A - T_D) = 92$ B.t.u. The net heat removed is $117 - 15 + 1{,}514 - 92 = 1{,}524$ B.t.u.

The efficiency is then $\frac{3{,}000 - 1{,}524}{3{,}000}$, or 49.2 per cent.

It will be seen by these two examples that, theoretically, the Hult engine should be considerably more efficient than the standard Otto engine for the same allowable temperature at the end of compression. But the large compressor cylinder would in all probability offset to a considerable degree the apparent thermodynamic advantage. This cylinder must in fact be larger than the working cylinder if the claim of "a denser air charge" is to be substantiated. The quantity of fluid handled per stroke is fixed by the compressor, and as this takes in air at atmospheric pressure and temperature, it must be larger than the working cylinder to fill the latter at the lower temperature. The ratio of the displacements of the two cylinders is the same as that of the absolute temperatures at D and A, or

$\frac{\text{volume compressor}}{\text{volume working cyl.}} = \frac{540}{433} = 1.25$ in the theoretical case and $\frac{540}{474} = 1.14$ in the second or practical case.

The weights of charge handled by the Hult engine per stroke are respectively 1.25 and 1.14 times as great as that of the ordinary engine with the same size working cylinder. Since the efficiency is also higher, the work performed per cycle is greater in the Hult engine than in the Otto in the ratio $1.25 \times \frac{54.0}{42.6} = 1.58$ in case 1 and $1.14 \times \frac{49.2}{42.6} = 1.32$ in case 2. In other words, a gain of either 58 per cent or 32 per cent in power is secured with an increase of 125 per cent or 114 per cent, respectively, in the cylinder volume.

A Summary of Research in Engineering Colleges

By A. A. POTTER

Dean of Engineering Schools and Director of Engineering Experiment Station, Purdue University

RESEARCH in engineering colleges is being carried on either in organized research departments, usually called engineering experiment stations, or by individual teachers. Organized research is generally carried on in state-supported engineering colleges. The following summary is intended to show the variety of projects the results of which have been published by the organized engineering college research departments and which are of particular interest to power producers and users. Ordinarily, these publications may be secured without charge by addressing the dean of the engineering college. In some cases a nominal charge is made for such bulletins.

1. *University of Illinois Engineering Experiment Station,* Urbana. Organized engineering research was started in this institution in 1903. Up to December, 1928, there had been published 187 bulletins and 17 circulars. Those pertaining to power generation include:

(*a*) Tests of Coal (including steaming tests, carbonization, spontaneous combustion and storage of Illinois coal). Bulletins Nos. 7, 15, 17, 24, 37, 38, 39, 46, 60, 69, 76, 79, 88, 89, 97, 100, 111, 116, 125, 128, 144, 180.

(*b*) The Occluded Gases in Coal, Bulletin No. 32.

(*c*) Gas Producers, Bulletins Nos. 30, 50.

(*d*) Fuel Economy of Hand-Fired Power Plants, Circular No. 7.

(*e*) Heat Transmission, Bulletin No. 40.

(*f*) Heat Transmission Through Boiler Tubes, Bulletin No. 168.

(*g*) The Thermal Conductivity of Fireclay at High Temperatures, Bulletin No. 36.

(*h*) The Thermal Expansion of Fireclay Bricks, Bulletin No. 181.

(*i*) Resistance of Firebrick to Slag Erosion, Circular No. 17.

(*j*) The Cause and Prevention of Embrittlement in Boiler Plate, Bulletins Nos. 155, 177.

(*k*) Tests of Tubes to Collapse, Bulletins Nos. 5, 99.

(*l*) Properties of Ammonia Vapor, Bulletin No. 66.

(*m*) Properties of Steam, Bulletin No. 75.

(*n*) Thermodynamic Analysis of Gas Engine Tests, Bulletin No. 150.

(*o*) Clayton's Analysis of Cylinder Performance of Reciprocating Engines, Bulletin No. 58.

(*p*) Gas Engine Cycles, Bulletin No. 160.

(*q*) Boiler Losses, Bulletin No. 78.

(*r*) Mechanical Stresses in Transmission Lines, Bulletin No. 54.

(*s*) Investigation of the Fatigue of Metals, Bulletins Nos. 124, 136, 142, 152, 156, 164, 176, 183.

2. *Iowa State College Engineering Experiment Station,* Ames, Iowa. Organized engineering research was started in this institution about the same time as that at the University of Illinois (early in 1904). Up to December, 1928, the results of the Iowa State College engineering investigations have been published in 90 bulletins. Those pertaining to power generation include:

(*a*) Steam Generation with Iowa Coal, Bulletins Nos. 9, Vol. I; 3, Vol. III, 29.

(*b*) Storage of Iowa Coal, Bulletin No. 48.

(*c*) Steam Pipe Covering Tests, Bulletin No. 5, Vol. III.

(*d*) Iowa Fireclays, Bulletin No. 40.

(*e*) Oil Engines for Power Plants, Bulletin No. 42.

3. *Pennsylvania State College Engineering Experiment Station,* State College, Pa. Organized in 1908. The publications related to power generation include:

(*a*) Substitutes for Gasoline in Engines, Bulletins Nos. 7, 10.

(*b*) Purchasing and Sampling Coal, Bulletin No. 14.

(*c*) Determination of Ultimate from Proximate Analysis of Coal, Bulletin No. 21.

(*d*) Heat Transmission, Bulletins Nos. 30, 32.

(*e*) Tangent Method of Analysis of Internal-Combustion Engine Indicator Cards, Bulletin No. 35.

4. *University of Kansas Engineering Experiment Station,* Lawrence, Kan. Organized in 1908. The publications concerned with power generation include:

(*a*) Natural Gas: Properties, Uses and Measurement, Bulletins Nos. 2, 11.

(*b*) Kansas Fuels: Coal, Oil, Gas, Bulletins Nos. 3, 6.

5. *University of Missouri Engineering Experiment Station,* Columbia, Mo. Organized in 1909. The publications pertaining to power generation include:

(*a*) Tests of Missouri Coal (including boiler tests, chemical analysis and storage), Bulletins Nos. 1, Vol. 2; 3, Vol. 3.

(*b*) Tests of Lubricating Oils, Bulletins Nos. 2, Vol. 4; 4, Vol. 4; 27.

(*c*) Heat Transmission Through Boiler Tubes, Bulletin No. 18.

6. *Kansas State Agricultural College Engineering Experiment Station,* Manhattan, Kan. Established 1910. Only Bulletin No. 2 on Boiler Room Economics and Bulletin No. 14 on Ventilators are related to power plant practice.

7. *Ohio State University Engineering Experiment Station,* Columbus, Ohio. Organized in 1913. Publications up to December, 1928, include 47 bulletins and 16 circulars. Those related to power generation include:

(*a*) Superheated Steam, Bulletin No. 4.

(*b*) Ohio Coal (including supply, classification, carbonization and tests), Bulletins Nos. 12, 22, 29, 46; Circular 11.

(*c*) Flash and Burning Points of Kerosene-Gasoline Mixtures, Bulletin No. 18.

(*d*) Economical Utilization of Liquid Fuels, Bulletin No. 19.

(*e*) Effect of Stratification of Furnace Gas on Steam Boilers, Bulletin No. 34.

8. *Washington State College Engineering Experiment Station,* Pullman, Washington. Established in 1914. Of the 25 publications issued, those pertaining to power include:

(*a*) Tests of Pipe Covering, Bulletin No. 12.

(*b*) Critical Velocity of Steam with Counterflowing Condensate, Bulletin No. 13.

9. *University of Wisconsin Engineering Experiment Station,* Madison, Wis. About 65 engineering research bulletins and six circulars have been published by the University of Wisconsin. Most of these were issued before the organization of the Wisconsin Experiment Station in 1914. Those related to the power industry include:

(*a*) Current Practice in Steam Engine Design, Bulletin No. 5, Vol. IV.

(*b*) Long Distance Transmission of Steam and Its Effect on Power Plant Economies, Bulletin No. 3, Vol. VI.

(*c*) Heat Insulating Properties of Steam Pipe Coverings. Reprint from Vol. 37 of the Transactions of the American Society of Mechanical Engineers.

(*d*) Economical Combustion of Soft Coal, Bulletin No. 7, Vol. VIII.

10. *Texas Engineering Experiment Station,* College Station, Tex. Organized in 1914 and publications include 29 bulletins and six circulars. Only Bulletin No. 3, on the Comparative Value of Fuels, is of interest to the power industry.

11. *University of Maine Technology Experiment Station,* Orono, Me. Established in 1915 and publications include about 21 bulletins and five circulars. The only publication that is concerned with power generation is Bulletin No. 4, dealing with Tests of Gasoline and Mixed Fuels in Internal-Combustion Engines.

12. *Purdue University Engineering Experiment Station,* Lafayette, Ind. Established in 1917 and is concerned mainly with investigations pertaining to railway engineering, automotive engineering, high-voltage transmission, limestone, concrete, hydraulics and manufactured gas. The publications related to the power industry include:

(*a*) Tests of Carburetors for Internal-Combustion Engines, Bulletins Nos. 5, 11, 15, 17, 21, 27, 31.

(*b*) Steaming Tests with Indiana Coal, Bulletin No. 26.

(*c*) Spontaneous Combustion in Storage of Coal, Bulletin No. 30.

(*d*) Flow of Water, Bulletins 1, 8, 32.

13. *University of Washington Engineering Experiment Station,* Seattle, Wash. Established in 1917 with the following publications related to power generation and distribution:

(*a*) Coal Washing, Bulletin No. 28.

(*b*) Intakes for High Velocity Flumes, Bulletin No. 33.

(*c*) Centrifugal Fans: Performance Characteristics and Methods of Testing, Bulletin No. 34.

(*d*) Hydro-Electric Power in Washington, Bulletin No. 36.

(*e*) Transmission Line Design, Bulletins Nos. 17, 29, 32, 44.

14. *Department of Engineering Research, University of Michigan,* Ann Arbor, Mich. Organized research was started in 1920. Up to date eleven bulletins, one circular and three reports have been published; of these the following are of interest to the power industry:

(*a*) The Stability of Metals at Elevated Temperatures, discussed in Bulletin No. 11.

(*b*) Properties of Ferrous Metals at Elevated Temperatures, contained in Report No. 3.

15. *Cornell University Engineering Experiment Station,* Ithaca, N. Y. Cornell University is one of the oldest engineering research institutions in the United States. Before the establishment of the Cornell Engineering Experiment Station (1923) the results of the investigations carried on were published in the techincal press and in papers before engineering societies. Since 1920 the following bulletins related to the power industry were published:

(*a*) Empirical Relations for Coals in theUnited States, Bulletin No. 3.

(*b*) The Design and Performance of Complete Cylindrical Bearings from the Mathematical Theory of Lubrication, Bulletin No. 2.

(*c*) Double Integraph for Electric Line Transients, Bulletin No. 4.

(*d*) The Heat Transfer from Steam to Heavy Oil, Bulletin No. 7.

(*e*) Efficiencies of Otto and Diesel Engines, Bulletin No. 8.

(*f*) On Experimental Representation of Low-Frequency Surges in Large Interconnected Electric System by Means of Equivalent Networks, Bulletin No. 10.

16. *Other Organized Research Departments.* Since 1920 Engineering Experiment Stations have also been organized at the Universities of Arkansas (1920), Maryland (1921), Minnesota (1921), Tennessee (1921), Nevada (1921), Vermont (1921), West Virginia (1921), Nebraska (1923), Montana (1924), Rutgers (1926), and Idaho (1928); also at the Virginia Polytechnic Institute (1921), Clemson College, South Carolina (1924), Michigan State College (1924), Oklahoma State College (1926), South Dakota State College (1926), and Oregon State College (1928). The publications of these stations have not included bulletins directly related to power generation.

17. *Massachusetts Institute of Technology.* This institution, like Cornell University, is among the pioneers in engineering research, but the results have been published in papers before engineering societies and in technical articles or reports.

In December, 1928, there were organized research departments in 38 state-supported engineering colleges, which have published a total of about 875 bulletins. From the foregoing summary it is evident that only a small portion of the publications named are concerned directly or indirecly with power generation and distribution. Is the power industry sufficiently interested in new knowledge to encourage research at engineering colleges?

[*The article in the April 2 issue will deal with "The Research Activities of the A.S.M.E."—Editor.*]

Oscillograph Used to Measure Mechanical Actions

IN A PAPER, "Use of the Oscillograph for Measuring Non-Electrical Quantities," by D. F. Miner and W. B. Batten, presented at the recent Winter Convention of the American Institute of Electrical Engineers, methods of using an oscillograph for measuring rate of travel, rotational speed, vibration, pressure, etc., are described. The authors say:

Although the electromagnetic oscillograph was developed primarily for, and has found its principal application in, recording electrical quantities in terms of current, voltage and watts, its inherent characteristics have made it useful for non-electrical applications. This oscillograph offers a means of recording photographically phenomena that are of too short a duration for the eye to watch or for other types of instruments to record. Furthermore, it is frequently desirable to record simultaneously both electrical quantities and mechanical actions of some apparatus. For this the oscillograph is admirably adapted. However, these quantities must be of such a nature that they can be translated into electric potentials or currents which have a definite relation to the quantities to be recorded.

The problem in adapting the oscillograph for other than electrical uses lies in the translation of the phenomena to be recorded, into proportionate electrical values. Many phenomena, such as changes in pressure, vibrations, stresses and time intervals, give rise to mechanical motion, either linear or angular, resulting in a variation of speed or an acceleration of the body as a whole or in part. If this motion can be made to vary an impedance in an electrical circuit as a function of this motion, the current through the circuit, or the potential across a portion of this impedance, may be utilized to actuate the galvanometer for a record.

A Method for Determining

Velocity of Circulation

IN WATER-WALL TUBES

By Elmer S. Smail

The high rates of steam generation obtained in furnace water walls and their increasing general use have served to stimulate the attention given to the water circulation in them. The calculation of the velocity of water and steam mixture in the tubes of water walls is at best complex. The author has simplified this determination to a great extent.

ALTHOUGH for many years engineers have agreed that high-speed circulation is desirable in a water-tube boiler, it is true that to date little is known about the actual value of the water velocity in feet per second. A few attempts have been made to determine the speed under various conditions by mechanical means.

Bulletin No. 325 of the Department of the Interior reports some tests made in 1904-6, where light-weight propellers were placed in various tubes of a straight-tube boiler and the revolutions noted. The author of the bulletin made no claim for a definite determination of velocity with this device, but thought that the readings were of value for the comparison of velocities in various tubes.

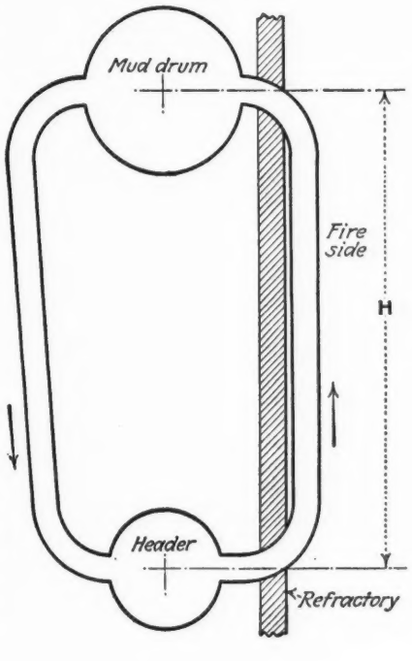
Some work has been done with pitot tubes, but no very convincing results have been obtained. The result is that we are dependent on mathematical analysis for data on this important subject, and unfortunately the mathematics of the problem is far from simple. It is probably true that the majority of boiler designers make no mathematical study whatever of the water speed and still turn out a product satisfactory to a degree. At first sight this seems to indicate that the matter is of no practical value, but the explanation is that water-tube boilers have been designed, built and operated for many years. The more faulty designs have been eliminated, while the more nearly perfect ones have been retained and refined with the result that many present-day designs give good results even though no conscious study of water velocity has been made on them.

This method of trial and rejection of errors is expensive, and it is to be hoped that it will not be necessary to go through that process with the "water wall." A furnace water-wall tube receives heat mostly by radiation, in distinction to the bulk of the boiler-heating surface, back of the first tubes, where the transfer is by conduction and convection. Transfer rates are high with radiant heat, making the necessity for adequate water velocities in furnace-wall tubes far more important than in the average boiler tube. A tube in a water wall may easily operate at 1,000 per cent of nominal rating on a surface basis, and should be designed just as carefully as a boiler for operation at a similar rating.

The usual method of mathematical analysis of a boiler condition is the consideration of the U-tube with the down-comer full of water and hence heavier than the up-comer, which contains water and steam bubbles. The difference in the pressure of the two legs is expressed as feet in terms of the ejected liquid, and the exit velocity equals $\sqrt{2gh}$, where g has the value 32 and h is the head referred to. This is substantially the same as the method of figuring the draft produced by a chimney, but is far less accurate than the usual chimney formula because of the lack of definite information as to the specific gravity of the lighter liquid, that is, the mixture of water and steam in the up-comer, and the absence of allowances for friction which every stack calculation requires.

With absorbtion essentially by radiant heat the amount of steam produced is practically uniform per square foot, which makes the calculation of water velocity in a water wall somewhat simpler than in a boiler where the heat absorbed per unit area is reduced as the furnace gases cool. The following is an attempt to show a method of calculation which will apply to water-wall tubes. The writer is well aware of the vulnerability of some of his assumptions and the questionable nature of the allowances for hydraulic friction. The defense is that with the method established, corrections can be applied as desired by anyone who will tolerate the additional mathematical complications.

Fig. 1—Diagram of furnace water wall arrangement



In Fig. 1, it is assumed that water flows down the down-comer to the left and reaches the bottom at the boiling point. It enters the up-comer at the right with a velocity of V feet per second. In the up-comer heat is absorbed, which produces steam, the amount depending on heat absorbed and the latent heat at the pressure prevailing at the average depth.

It will be further assumed that the heat absorbed in the up-comer is uniform per square foot, in accordance with Stefan's law for radiant heat, it being considered that the furnace radiation temperature is uniform along the up-comer length.

The following symbols will be used;

H = the vertical height in feet as shown;

L_u = the tube length in feet of up-comer, L_d = length of down-comer;

A = the tube internal cross-section area in square feet of up-comer;

Q = the volume of steam produced per second as calculated from the formula for radiant heat transfer, the latent heat of steam, and the specific volume;

D = the weight of a cubic foot of water at average temperature;

V = the water velocity at the bottom of the up-comer (this is an unknown quantity).

At the bottom of the up-comer, before the heat strikes the tube, there

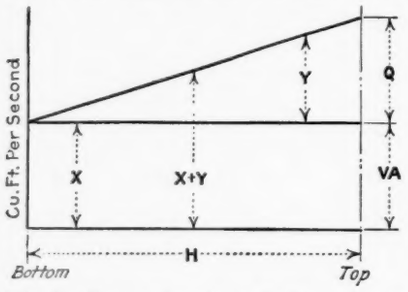


Fig. 2—Curve showing relative volumes of water and steam passing various portions of the exposed tube

is nothing but water and the amount entering is VA cu.ft. per sec. Steam is produced uniformly along the tube until at the exit Q cu.ft. per sec. is escaping. In Fig. 2, X represents the volume of water passing various portions of the tube. As the reduction in water volume is so slight compared to the volume of steam produced from it, we can consider this amount X as constant equals VA. Y is the steam volume passing, and for this particular case the amount increases uniformly from zero to Q. If at the top X and Y are equal, the tube is half full of steam and half full of water. At any point the fraction of the tube filled with water is $\frac{X}{X+Y}$

This fraction also represents the specific weight; that is pounds per cubic foot of the material in the tube as compared to water. Let F_e indicate the fraction at the top of up-comer. Then $F_e = \frac{VA}{VA+Q}$ Fig. 3 shows the variation of the fraction of water along the exposed tube length. To get the average fraction of water F_a, we, in effect, find the average height of the curve in this figure. Fortunately, on account of the uniform nature of steam production this can be readily accomplished by the calculus, z being the variable height.

$$F_a = \frac{1}{H}\int_0^H \frac{VA\ dz}{VA+Z\frac{Q}{H}} = \frac{VA}{Q}\ \text{Log}_e \frac{VA+Q}{VA} = \frac{VA}{Q}\text{Log}_e\frac{1}{F_e}$$

This logarithm is the natural logarithm which equals the common logarithm to the base 10 multitplied by 2.302. In terms of common logarithms,

$$F_a = \frac{(2.302)\ VA}{Q}\log\frac{1}{F_e}$$

We now have a down-comer of height H filled with water of weight D lb. per cu.ft. and an up-comer of equal height filled with a mixture of weight F_aD lb. per cu.ft. The unbalanced pressure, $H(D-F_aD)$ lb. per sq.ft., produces the velocity and overcomes the friction in the circuit. To translate this pressure in terms of head of ejected material, we must divide by the specific weight F_eD of ejected material, thus forcing head in feet is

$$\frac{H(D-F_aD)}{F_eD} = \frac{H(1-F_a)}{F_e} = h.$$

This is the h in the usual velocity formula. This forcing head measured in feet must equal the sum of the velocity head and the equivalent head of each friction loss. These will now be considered for both up-comer and down-comer, and it is important to remember that they must all be in the terms of the ejected fluid like the forcing head.

$$\text{Velocity head } H_v = \frac{(\text{exit velocity})^2}{2g} = \frac{\left(V+\frac{Q}{A}\right)^2}{2g} = \frac{V^2}{2gF_e^2}$$

Entrance loss head is obtained from the hydraulic formula and equals for corners not rounded, and tubes entering normal to the drum $0.505\frac{(\text{velocity})^2}{2g}$

Up-comer entrance loss head

$$H_{ue} = \frac{0.505\ V^2}{2g\ \ F_e}$$

For the down-comer loss we must know R, which is the ratio of up-comer area to down-comer and is unusually greater than unity.

Down-comer entrance loss head

$$H_{de} = \frac{0.505\ (VR)^2}{2g\ \ F_e}$$

Skin friction depends on length of the tube, the character of the internal surface and the diameter. A common formula is

$$\text{Friction head} = \frac{0.024\ L}{d} \times \frac{(\text{velocity})^2}{2g}$$

where L is length and d is the tube diameter, both in feet. For rough tubes the value 0.024 should be increased. The velocity in this formula is the average velocity which in the up-comer is constantly increasing and in the down-comer is constant.

Up-comer skin friction head

$$H_{uf} = \frac{.024Lu}{d} \times \frac{V^2}{2g\ F_a\ F_e}$$

Down-comer skin friction head

$$H_{df} = \frac{.024Ld}{d} \times \frac{(VR)^2}{2g\ F_e}$$

Impact head loss is caused by the sudden reduction in velocity where the material in the tubes enters the more nearly quiet material in the drums.

$$\text{Impact head} = K\frac{(\text{velocity})^2}{2g}$$ where K is a co-efficient depending on the relative areas before and after sudden enlargement, $K = \left[1 - \frac{\text{smaller area}}{\text{larger area}}\right]$

Impact head up-comers

$$H_{ui} = \frac{K_u}{2g}\left(\frac{V}{F_e}\right)^2$$

Impact head down-comer

$$H_{di} = \frac{K_d}{2g}\frac{(VR)^2}{F_e}$$

Forcing head h must equal $H_v + H_{ue} + H_{de} + H_{uf} + H_{df} + H_{ui} + H_{di}$, and we have already identified each of these quantities in terms of known items and the velocity term V. It is quite improbable that this complicated equation can be algebraically solved for V, and the most practical method is repeated assumptions for the value of V until the equation is satisfied. It is not always essential to calculate the actual values of the various items and the equation can be modified, greatly simplifying the labor of substitution.

$$H(1-F_a) = \frac{V^2}{2g}\left[\frac{1+Ku}{F_e} + .505 + .505\,R^2 + K_d\,R^2 + \frac{.024}{\text{diam.}}\left(\frac{L_u}{F_a} + L_d\,R^2\right)\right]$$

An example will illustrate the method. Consider a case similar to Fig 1, which may represent a bridge wall cooling system. This is considered as operating at 200 lb. absolute pressure with a furnace temperature of 2,500 deg. F. The tubes are 4-in. No. 9 gage. H is assumed to be 12 ft. with an up-comer length of 14 ft. Down-comers are taken as the same length and diameter, and half the number, that is, $R = 2$. For simplicity it is assumed that the change in area from down-comer to bottom

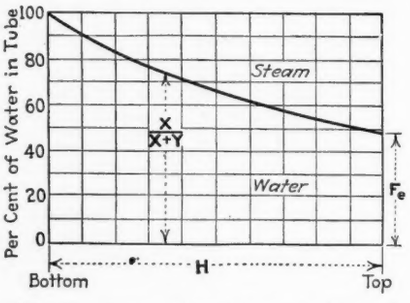


Fig. 3—Curve showing variations of fraction of water in tube

header and from up-comer to drum is in the ratio of 1 to 2; then K_u and K_d equal each 0.25. The area of the up-comer equals 0.075 sq.ft.

The rate of heat transfer in B.t.u. per hour per square foot equals

$$1{,}600\left[\left(\frac{T}{1{,}000}\right)^4 - \left(\frac{t}{1{,}000}\right)^4\right]$$

where T is the absolute temperature of the hot body and t the absolute temperature of the cold body. For this particular case 121,968 B.t.u. will be absorbed for every square foot of projected area of tube, giving a value of 0.368 cu.ft. per sec. for Q. This is probably greater than can be expected in ordinary practice. After repeated

assumptions of values for V it is found when $V = 4.59$ ft per sec. that,

$$F_e = \frac{VA}{VA+Q} = \frac{(4.59)\ (0.075)}{(4.59)\ (0.075) + 0.368} = 0.483$$

$$F_a = \frac{2.302\ VA}{Q} \log \frac{VA+Q}{VA} = \frac{(2.302)\ (0.344)}{0.368} \log \frac{0.712}{0.344} = 0.682$$

The left-hand side of the equation then becomes (12) (1 — .682) = 3.82 The right-hand member is found to be:

$$\frac{(4.59)\ (4.59)}{64}\left[\frac{1.25}{0.483} + 0.505 + (0.505)\ (4) + (0.25)\ (4) = \frac{0.024}{0.333}\left(\frac{14}{0.682} + (14)\ (4)\right)\right] = 3.82$$

This establishes the accuracy of the assumption, and 4.59 ft. per sec. is the velocity at the bottom of the up-comer. The down-comers have a uniform velocity of 9.18 ft. per sec. because they are only half the number of the up-comers. The water enters the bottom of the up-comers at 4.59 ft. per sec. and steam starts to form. As it ascends, the velocity increases and the specific gravity of the mixture decreases until at the top the velocity is 9.72 ft. per sec. and the mixture is only 48 per cent water; that is, the tube is running 48 per cent full of water and 52 per cent full of steam. The curve in Fig. 3 shows this condition.

Calculation of the values of various heads involved for purposes of comparison is instructive. For this case, on a percentage basis we find:

	Per Cent	
Velocity head	18.3	
Down-comer entrance head	17.9	Total down-comer, 62.0 per cent
Down-comer friction head	35.3	
Down-comer impact head	8.8	
Up-comers entrance head	4.5	Total up-comer, 19.7 per cent
Up-comers friction head	13.0	
Up-comers impact head	2.2	
	100.0	

It is rather surprising that over 80 per cent of our forcing head is required to overcome various friction losses and quite astonishing that the down-comer losses exceed the up-comer losses, which indicates the desirability of avoiding designs where the down-comer area is materially less than the up-comer. Should we increase the down-comer area so that there is one down-comer for each up-comer and recalculate the values, we would find the exit velocity raised to 5.88 ft. per sec. and the water at exit 54 per cent, certainly a safer condition. Briefly stated, the more losses present in the circuit, the more steam there will be present in the up-comer tube. The greater the amount of steam in this tube, the greater is the tendency to blister. The design, therefore, should be directed toward the elimination of friction losses as far as possible.

Other interesting lines of study are the effect of increasing the vertical height and the effect of high pressure, which will decrease the volume of steam formed.

Cooling and Humidifying of Buildings*

By S. C. BLOOM

Consulting Engineer, Bloom & Kamrath, Chicago, Ill.

THE broad contact that the public has had with the comforts of cooling in the theater is resulting in widespread interest in the possibilities of application to all types of buildings, primarily for the purpose of escape from the elements during summer.

In the theater today the cooling system is an essential feature of the equipment, for experience has shown it to be an investment yielding large returns. It is only natural that the fields in which the benefits of cooling are of a tangible nature should be the earliest to adopt it. Hence, we see the hotels, stores and industrial plants beginning to utilize this effective auxiliary to attract the public and provide for its comfort while within their establishments.

The greatest field on the horizon, however, lies in the cooling of office buildings. It is more difficult to evaluate the direct benefits that accrue from the maintenance of conditions under which people can work to best advantage, but it is the common experience of everyone that when the weather is so hot and uncomfortable as to be distracting, there is a decided reduction in mental and manual capacity for work.

The problem of the engineer is to devise methods and means whereby the great benefits to be derived from the general usage of cooling can be attained. It is not an easy task, as anyone will quickly recognize who examines the subject, yet not insurmountable. The principal obstacles at the present time are the initial and operating expense of the equipment required according to current practice, the space requirements, and the lack of experience by which to determine the worth of the investment.

Lack of Experience Is Principal Handicap

The last factor named is perhaps the most important, yet we have some outstanding examples of office building cooling, covering many years' experience and it is the unanimous opinion of the managements that they could not afford to be without them.

The heat to be absorbed by the air supplied for cooling is preponderantly sensible—a characteristic that may prove important in the ultimate solution of the problem, through the objective of maintaining lower relative humidities than are now considered satisfactory, and higher room temperatures. It isn't the heat but the humidity that is the common complaint.

At the present time, air circulating systems, where cooling is employed, are designed much along the same lines as ordinary ventilating systems, except that the exhaust system is usually arranged for recirculating a substantial portion of the air supplied. Existing standards, whether traditional, code or statute, are, on the surface at least, adhered to.

Recirculation of air is done for the purpose of saving refrigeration, tempering the air supply and obtaining desirable humidity conditions in the building. The interesting point is that this results in a reduced intake of outdoor air. This immediately arouses speculation as to the minimum amount of outdoor air that must be introduced to a building.

There is a considerable body of evidence that has been accumulating for the last few years from various directions, indicating that the outdoor air requirement may be lessened without seriously impairing the quality of ventilation, especially with the use of ozone in odorless concentrations and the promising prospects of ionization as adjuncts.

Fresh Air Requirements Can Be Reduced

From the viewpoint of cooling its acceptance would be of tremendous significance for the reason that it would no longer be necessary to mask realities; recirculation of air could be dispensed with. Stripped naked, there would remain a simple system supplying a relatively small quantity of cold, purified, outdoor air to the spaces ventilated.

Indeed, exhaust systems may well be eliminated, thus requiring the air to find its escape through leakage and to that extent reduce infiltration of outdoor air—a factor of large consequence in air and refrigeration requirements.

If air supply can be reduced to a point that approaches the normal infiltration—a not unreasonable prospect, considering that occupied area will rarely be less than 30 sq.ft. per person—it will be seen that an important avenue of progress is opened.

The less air supplied the colder it must be of necessity, and the lower will be the relative humidity in the ventilated spaces and the higher the temperature for a given comfort effect. This all works in the direction of smaller conduits for the air supply system and with the omission of a recirculating system to a large saving in space requirements.

Consider, in addition, the possibilities of increasing air velocities in the main conduits to five or six times those commonly used and of operating blowers at pressures ranging upward to one pound per square inch instead of the customary range. In dealing with greatly reduced air volumes, the total power requirement for air circulation will compare favorably with conventional systems.

The raising of air pressures on the mains will go far to solve the problems introduced by the chimney effect in a building where many stories are interconnected by a common piping system. Similarly, the maintenance of sufficient

*Abstract of paper presented at A.S.H. & V.E. annual meeting, Chicago.

pressure at branches will facilitate meeting the effects of windage.

There remains only the question of introducing the cold air to the enclosures in such a way as to prevent drafts. The lines along which this problem can be met are quite well known. Briefly, it is through the use of very small columns or thin streams of air, introduced in a direction and at a speed that will effect their admixture with the room air before the cooled air falls to the occupied zone.

During the heating season the same system could be used to moisten the air by the simple expedient of using a relatively small quantity of highly humidified air, the dewpoint of the air supplied being varied as outdoor conditions change, thus keeping the relative humidity in the rooms within a satisfactory range.

In the broad outline of the system described, the thought has been primarily to suggest some avenues of approach to a problem, upon the threshold of which we stand; a problem demanding a satisfactory solution and requiring the earnest thought of every heating and ventilating engineer.

Avoid Large Changes in Temperature

A tendency that ought to be discouraged is the effort to maintain temperatures too low. It is not only expensive, but unnecessary and even undesirable. A sane temperate view of the matter should be taken. A condition of 85 deg. F. and 40 per cent relative humidity would be unbearable in a room during the heating season, and yet be gratefully comforting when it is 95 deg. F. and 50 per cent relative humidity outside. The provision of a reasonable contrast between indoor and outdoor conditions should be the objective. Excessive cooling in summer is just as objectionable as overheating in winter.

A principle that may offer a basis for an indoor temperature and humidity schedule in summer, is that the necessary readjustment of the body heat controls in passing from outdoors to indoors and vice versa should be a minimum commensurate with suitable comfort contrasts.

If it be assumed that an effective temperature of 66 deg. in the environment of an average person at rest and normally closed, is the condition wherein the body heat generated is thrown off with the greatest facility and the least discomfort, then it would seem reasonable that the maintenance of an effective temperature indoors, midway between that prevailing outdoors and 66 deg. would afford the maximum comfort contrast with the minimum disturbance in the body temperature control mechanism of those passing indoors and outdoors.

On such a schedule the contrasts would lessen as summer weather conditions recede from the extreme, until with 66 deg. effective temperature outdoors the contrast would vanish. There could, of course, be various combinations of temperature and humidity indoors to produce the required effective temperature.

It is common experience that after a protracted period of warm weather people become accustomed to it to a considerable extent. In other words, there seems to be a seasonal adjustment of the body temperature controls, during which time we are quite conscious of discomfort. After the adjustment has been completed, the discomfort lessens.

The prospect of providing for the comfort, happiness, well-being and efficiency of the great body of people compelled to work in buildings by virtue of the necessity of earning a livelihood, ought to stimulate the imagination and ingenuity of engineers and thereby reflect great credit upon our profession.

Recent Publications

Mathematical Tables and Formulas. By P. F. Smith and W. R. Langley, Professors of Mathematics in Yale University. Published by John Wiley and Sons, New York City, 1929. Imitation leather; 5x8 in.; 66 pages. Price, $1.60.

THIS boiled-down collection of tables and formulas is intended primarily as a handbook for the use of university students. Its compactness will commend it also to practicing engineers as an auxiliary to more bulky and comprehensive collections. The longer tables are carried to four places of figures with proportional parts for computation of the fifth place. The list of tables follows: Numerical constants and their logs; squares of numbers; cubes; square roots; cube roots; reciprocals; natural trigonometric functions; common logs; minutes to radians; degrees to radians; radians to degrees and minutes; antilogs; log sines; log tangents; exponentials; hyperbolic functions; naperian logs. The latter part of the book gives selected formulas from algebra, geometry, trigonometry, analytic geometry and calculus.

Photomicrographs of Iron and Steel. By Everett L. Reed, instructor in Metallurgy, Harvard University, with a foreword by Dr. Albert Sauveur, Gordon McKay Professor of Metallurgy and Metallography, Harvard University. Published by John Wiley & Sons, Inc., New York, 1929. Cloth; 6x9 in., 218 illustrations, 253 pages. Price, $4.

THOSE who specialize in the metallurgy of iron or steel, or even those who dabble in it to some extent, will find much of interest in this volume. But it is not a work for the uninitiated and is not so intended.

Primarily, it consists of photographic reproductions of a set of 218 photomicrographs of pure iron, commercial iron, wrought iron, steel and alloy steels, cast iron and semi-steel, exhibiting the untreated metal, the metal after various treatments and the effects of impurities. These illustrations are clearly and beautifully made, and the captions accompanying are sufficiently complete to explain to the reader what the specimen represents.

Appendices deal with the preparation of metallographic specimens; the composition and use of etching solutions, microscopes and cameras, photomicrography and definitions of terms.

Here is a work that should prove of high utility to the student and the working metallurgist. Readers in other fields may well envy the quality of its illustrations.

Oxy-Acetylene Welding of Steel Pipes. Report of Sub-committee on Pipe Joints. Published by the American Gas Association, Inc., 420 Lexington Ave., New York, 1929. Paper, 7x10 in.; 732 pages; diagrams, tables and photographs.

THE interest of this practical treatise on pipe joints is by no means confined to the gas industry. There is no essential difference between pipe joints for gas and those for steam, compressed air and other fluids. Strength and tightness are in all cases the requirements. Because of the relative newness of the oxyacetylene process as applied commercially to the welding of pipe joints, the literature on the subject is still not very extensive, although it is growing rapidly. This is perhaps as complete a discussion of the subject as has yet been produced in book or pamphlet form. The pamphlet is strictly practical in nature, and its reliability is vouched for by men with extensive experience in this field.

Part 1 gives the results of many tests made to determine the strength of various types of oxyacetylene welded joints and includes tests made on full-sized pipe sections. Part 2 is devoted to cost data and gives the necessary information for estimating purposes. Parts 3 and 4, giving the procedure control for steel pipe joints and for the fabrication of fittings, are perhaps the most important of all in the present stage of the art. Procedure control is placing oxyacetylene welding on a sound and reliable basis, just as control has dispelled the doubts and questionings that surrounded the early use of reinforced concrete. The two cases are similar. An appendix gives templet design for various types of joints, including reducing connections and bull plugs. Part 5 describes joint practice as applied to long-distance high-pressure gas transmission lines. This booklet should be in the hands of every engineer whose work involves the installation or extension of pipe systems.

Events and Men in Power's Field

THE EDITORS WILL WELCOME THE CO-OPERATION OF READERS IN REPORTING INTERESTING HAPPENINGS, PERSONAL OR OTHERWISE

Aviation Joins McGraw-Hill Group

Pioneer Journal in the Air Transportation Field will Hereafter be Issued in New York by the Publishers of *Power*

AS ANNOUNCED in its columns on March 2, *Aviation* transfers during the current month to the ownership of the McGraw-Hill Publishing Company. This journal is a pioneer in the aëronautical field, having been established thirteen years ago. Since then it has had a continuously successful existence and is now widely recognized as the leading paper in its field. In joining the McGraw-Hill organization, *Aviation* adds to its present strength the backing and experience of the world's largest publisher of business, engineering and industrial magazines.

Aviation is closely concerned with the fields of other papers in the McGraw-Hill group. In production interests it will co-operate with *American Machinist* and *Factory* and *Industrial Management*. It will supplement the promotion of airport construction and lighting undertaken by *Engineering News-Record* and *Electrical World*. *Chemical and Metallurgical Engineering* will join it in solving the problem of obtaining better materials for airplane construction. And *Power* will co-operate with *Aviation* on problems of supply of power for manufacturing and in encouraging the development of better engine designs for airplane drive.

The air transportation business is experiencing a steady and remarkable growth. Already it represents more than a hundred millions of invested capital. Ten thousand planes will be built in 1929 and the production of the industry, valued at $9,000,000 in 1927 and $20,000,000 in 1928, will show a great increase. Flying fields and airports spring up all over the country with astonishing rapidity, and the network of air routes already rivals the railroads and bus lines in covering the country. More and more mail is carried by plane each month and the day is not far off when first-class mail will mostly move this way.

It is this rapidly expanding field that *Aviation* serves; and that it is qualified to do so is evidenced by the fact that five of its editorial staff are licensed air pilots and a sixth is now being instructed. Its field includes aircraft manufacture, engines and parts, airports and service to distributors and all others professionally engaged in aëronautics.

Earl D. Osborn, publisher of *Aviation*, and James H. McGraw, chairman of the board of the McGraw-Hill Publishing Company, both point out, in their announcements of the merger, that it will mutually strengthen the two groups. Improved service to the aëronautic industry and increased awareness by other industries of the part air transportation is to play are stated as outgrowths to follow this new connection.

Research on Mechanical Springs Going Forward

With the widespread support of industry during the first year of actual research, the A.S.M.E. Special Research Committee on Mechanical Springs has attained several definite objectives.

During 1928 the laboratory facilities of Union College, Schenectady, were used for a start on the committee's program under the direction of Prof. M. F. Sayre, and the committee's research associate, Anthony Hoadley.

The committee has undertaken a study of the fatigue and the fatigue-corrosion properties of spring materials, and has obtained the facilities of the U. S. Naval Experimental Station at Annapolis, Md., and the services of Dr. D. J. McAdam, Jr., who is at present supervising the experimental work.

Experiments are being conducted for the committee at Lehigh University, Bethlehem, Pa., by M. S. Gjesdahl for the purpose of confirming the theoretical deductions of Prof. J. B. Reynolds, also at the university.

A comprehensive bibliography on mechanical springs, containing over 700 references cross-indexed as to author, subject and data, was prepared by the committee and published by the American Society of Mechanical Engineers in December, 1927. This bibliography, judging from the testimony of those who have obtained copies, has proved to be a valuable aid to research drafting and designing.

Florida Power Builds State's Largest Hydro

Construction work on the largest hydro-electric generating plant in the State of Florida is being rushed to completion by the West Florida Power Corporation, National Electric Power subsidiary.

The plant is on the Ocklocknee River, twenty-six miles west of Tallahassee, state capital. When completed, it will have an installed capacity of 13,000 hp., in three units consisting of Newport News waterwheels and Westinghouse generators. It will be capable of producing annually 32,000,000 kw.-hr. of energy. Mechanical rack rakes and other devices are being installed to eliminate manual operation.

An earthen dam, already completed, will store approximately fifty billion gallons of water, creating a lake fifteen miles long and from one to four miles wide. Millions of feet of merchantable lumber are now being taken out of this area for manufacturing purposes.

When the Jackson Bluff plant is placed in operation, it will supply energy to north and west Florida, including the City of Tallahassee, and to the southern Georgia territory, served at present by Georgia Power & Light Company. The creation of an abundant power pool on the west coast of Florida is expected to prove an industrial and agricultural boon to the territory.

Men in the News

GARRETT BURGESS

who for twenty years has served the United States Rubber Company, his latest position being that of chief power and mechanical engineer of the Detroit plant and consulting engineer of the tire division of the company. Mr. Burgess has resigned to enter business for himself as head of Garrett Burgess, Incorporated, Detroit, Mich. The new company will act in a consulting capacity in the power and the mechanical engineering fields.

Boiler Installation Code Subject of Two Bills in N. Y. Legislature

Inspection of Construction and Alteration Would Be Required

ONE of the most drastic bills affecting construction work which has been introduced in the New York State Legislature in some years was recently presented to the Assembly by Mark C. Kelly, Democrat, of Utica. The measure brings under supervision of the Department of Labor all present and future installations of steam power and heating plants, whether in public or private buildings.

The bill is sponsored by the New York State Association of Journeymen Plumbers and Steamfitters and Steamfitter Helpers.

It provides for a code for installation, alteration and equipment of steam power and heating plants to be formulated by the industrial board. It sets up a division of steam power and heating plants in the Department of Labor to be in charge of a "person who has had not less than ten years' experience in the installation of steam power and heating plants."

It provides for the registration of master steamfitters and the payment of a fee of five dollars; for record of registration; for revocation of certificate for cause after hearing; it prohibits renewal of a revoked certificate within the period of one year, and makes provision for review of action revoking certificate by certiorari. It provides for the appointment of inspectors to inspect the construction and alteration of steam power plants and existing plants already installed.

Before any construction or alteration of existing buildings may be authorized by any local authority, the plans for the installation and alteration of steam power or heating plants shall be submitted to the industrial commissioner for approval. A ten dollar fee must accompany the plans. No steam power or heating plant hereafter installed shall be operated until approved by the industrial commissioner. The commissioner is given authority to order any existing plant not constructed in accordance with the code to be so altered as to conform thereto, but the owner of the property has the right of review of such order by certiorari. A person violating any of the provisions of the law would be guilty of a misdemeanor. The act would take effect July 1, 1929.

A second bill, introduced in the Assembly by Henry A. Samberg, Democrat, of the Bronx, would amend the labor law by providing that in a city of one million or more inhabitants no low-pressure boilers shall be installed in any building in such city unless the plans therefor conform to standards prescribed by the state industrial board. The tenement house department or other local authority is charged with the duty of annual inspection of all low-pressure boilers installed in the city to see that they conform to the standard requirements. If any low-pressure boiler so installed be found not to conform to the standards prescribed, or not so equipped as to prevent the escape of coal gas while in operation, such department may issue and enforce an order directing that such low-pressure boiler be so installed as to conform to the standards prescribed or so equipped as to prevent the escape of coal gas while in operation. This law would go into effect Oct. 1, 1929.

Summer Course at Harvard

The Graduate School of Business Administration, George F. Baker Foundation, Harvard University, will hold its second special annual session for business executives from July 1 to Aug. 10. In the five courses offered at the first session last summer, 172 business men and eight teachers of business subjects enrolled. The executives attending came from 95 different companies in 26 states. Most of them had been in business from eight to twenty years. Courses this year will be offered in the interpretation of financial statements, bank management, public utility management and economics, railway transportation, sales management and trust management.

At the last meeting of the Board of the Graduate School of Business Administration, Walter Gifford commented on the results obtained by the American Telephone & Telegraph Company in sending certain junior executives to this summer course. The results have been sufficiently beneficial and encouraging to lead his company to enter as many men in the second course as the School will take.

Group Meeting of A.S.T.M. in Chicago This Month

The four-day annual spring group meeting of the American Society for Testing Materials will be held in Chicago, Mar. 19-22, at the Hotel Stevens, according to an announcement of the society's secretary. A feature of the meeting will be the sessions of 27 committees which will discuss various branches of testing practice. Among these will be committees on corrosion of iron and steel, on corrosion of nonferrous metals and alloys, and on the fatigue of metals.

*Spot * News*

EIGHT HUNDRED AND FIFTY THOUSAND *pounds of steam per hour each will be the output of the world's record boilers now building by the Combustion Engineering Corporation to feed the 160,000-kw. turbine at the East River station of the New York Edison Company. There will be an acre and a half of heating surface in each boiler, and nearly a quarter of a million gallons of condensing water per minute will be required when the turbine is running at full load.*

* * *

TUNGSTEN CARBIDE, *otherwise known as "Carboloy," and recently placed on the market by the General Electric Company, has been cutting 16-in. armor plate at the Philadelphia Navy Yard. A new field of machining has been opened by this new tool material, which is almost as hard as diamond.*

* * *

THE MIDWEST ENGINEERING CONFERENCE *brought to light among other things the fact that in America it requires only 15 men to produce all the necessities of life for each 100 of the population. The other 85 are kept busy making articles of commerce and luxuries. High industrial horsepower per capita is the secret.*

* * *

DR. EDWARD WESTON, *founder of the Weston Electrical Instrument Corporation, has made an endowment of $25,000 to Columbia University to support a research fellowship in electrochemistry. Research into the borderland between electricity and chemistry, Doctor Weston believes, is vastly important to the industrial world.*

* * *

THE MUNICIPAL *hydro-electric plant of Loveland, Colo., froze up tight in a recent cold snap, so that the people were forced to resort to oil lamps and to get along without power. The Public Service Company of Colorado came to their rescue, however, and within a few hours a tie-in made it possible to restore full service to the darkened community.*

* * *

AN INCREASE *of 20 per cent in tuition fees has been put into effect by Pres. Harvey N. Davis at the Stevens Institute of Technology. The increase is in line with the general reorganization which Doctor Davis is making in order to obtain a broader engineering course.*

* * *

THE CHICAGO PUMP COMPANY, *as a stunt in connection with the conventions and exhibits at which its line is shown, will give away a "Little Giant" cellar drainer at each. The gift will be made to the winner of a lottery contest, it is understood.*

Vacancies in Civil Service for Testing Engineers

The United States Civil Service Commission announces the following open competitive examinations:

Materials testing engineer, $3,800 a year.

Associate materials testing engineer, $3,200 a year.

Assistant materials testing engineer, $2,600 a year.

Applications for these positions must be on file with the Civil Service Commission at Washington, D. C., not later than March 27. The examinations are to fill vacancies in the Bureau of Standards, Department of Commerce, Washington, D. C., and in positions requiring similar qualifications. Competitors will not be required to report for examination at any place, but will be rated on their education, experience and fitness.

Water Power Still Holding Its Own U. S. Geological Survey Finds

Gain of Ten Per Cent in Developed Hydro During 1928

WATER power in the public-utility field is holding its own in spite of the steadily increasing efficiency of fuel-burning plants, it is declared by A. H. Horton, chief of the Division of Power Resources, United States Geological Survey, as a result of detailed studies covering the last decade. Although predicting that the construction of hydro-electric plants may reach a saturation point as steam becomes more advantageous, Mr. Horton states that, contrary to current belief, this has not yet happened. Without reference to the economic, political or financial factors involved, all of which are subject to differing opinions, it is pointed out that the bare figures bringing the story up to date are indisputable. So far, definite trends are evident. Analyzing the hydro-power statistics, Mr. Horton says in part:

"Water power was used to generate 34,747,000,000 kw.-hr., or about 40 per cent of the total output of 87,851,000,000 kw.-hr. generated by public-utility power plants in 1928. It has generated more than one-third of the electricity produced by public-utility plants every year from 1919 to 1928. During the last four years the output by water power has increased more rapidly than the output by fuel power and in 1928 would have been more than the 40 per cent attained had it not been for abnormally dry weather in the latter part of the year, which reduced the water supply." It was also shown that while the developed hydro power increased at the rate of 5 per cent a year in 1926 and 1927, the gain was 10 per cent in 1928. The following table gives a summary of the past several years:

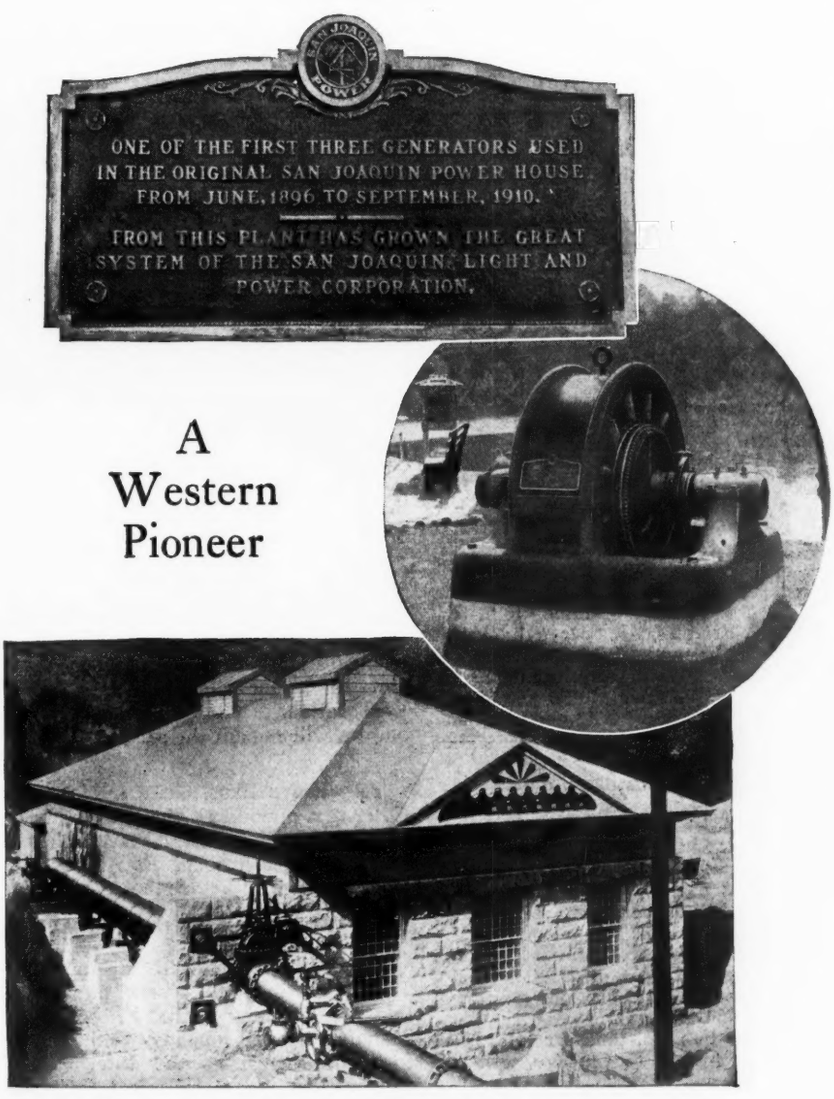
Date	Horse-power	Increase Horse-power	Increase Per Cent
1921 (Nov.)	7,926,958	.....	....
1924 (March)	9,08.,958	1,160,000*	14.6
1925 (March)	10,037,655	950,697	10.5
1926 (Jan. 1)	11,176,596	1,138,941†	11.3
1927 (Jan. 1)	11,720,983	544,387	4.9
1928 (Jan. 1)	12,296,000	575,017	4.9
1929 (Jan. 1)	13,571,530	1,275,530	10.4

*About 2.3 years. †About 0.8 year.

Public-utility statistics include about 80 per cent of the nation's electric output and 90 per cent of the hydro powers, thus serving as an accurate index in showing the trend of water-power development, it is pointed out. According to predictions, the ratio of hydro-electric power to the total production was to have fallen off before now. Nevertheless, this has not been the case, and many think that, short-time factors aside, water power will continue to keep pace with steam for some time to come.

Turning to the subject of increased fuel efficiency, Mr. Horton continues:

"Public utility companies and their power-plant operators were again successful last year in increasing the efficiency in the utilization of fuels in the generation of electricity. The average rate of fuel consumption for the entire United States in 1927 was 1.84 lb. of coal per kilowatt-hour; in 1928 the rate was reduced to 1.76 lb. This small saving per kilowatt-hour in generating the 53,000,000,000 kw.-hr. of fuel-generated electricity amounted to 2,120,000 tons in the year, which is equivalent to about $8,000,000. In 1919 the average rate of coal consumption in generating electricity was 3.2 lb. per kw.-hr. The rate of 1.76 lb. in 1928 is therefore close to half the 1919 rate. If coal had been


ONE OF THE FIRST THREE GENERATORS USED IN THE ORIGINAL SAN JOAQUIN POWER HOUSE FROM JUNE, 1896 TO SEPTEMBER, 1910.
FROM THIS PLANT HAS GROWN THE GREAT SYSTEM OF THE SAN JOAQUIN LIGHT AND POWER CORPORATION.
A Western Pioneer

IN JUNE, 1896, this generator went into service at Power House No. 1 of the San Joaquin Light & Power Company at Kerckhoff Lake, Calif. This plant was the first to be placed in service by the San Joaquin Company and was the foundation upon which has grown one of the largest electric systems on the West Coast.

Coming Conventions

American Institute of Electrical Engineers, annual summer convention, Swampscott, Mass., June 24-28; F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Institute of Refrigeration, at Washington, May, 1929. Louis Baron, secretary, 203 West 13th St., New York City.

American Oil Burner Association, annual convention, Hotel Pennsylvania, New York City, April 9-11, 1929. For information, address the headquarters of the Association at 420 Madison Ave., New York City.

American Society of Heating and Ventilating Engineers, annual summer meeting, Big Wind Inn, Lake of Bays, Ontario, Can., June 27-29. F. L. Hutchinson, secretary, 29 W. 39th St., New York City.

American Society of Mechanical Engineers, spring meeting, Salt Lake City, Utah, July 1-4, 1929. Rochester regional spring meeting, Rochester, N. Y., week of May 13. Calvin Rice, secretary, 29 West 39th St., New York City.

Association of Iron and Steel Electrical Engineers, 25th annual convention, Pittsburgh, Pa., June 17-22, 1929. A. A. Stewart, secretary, Pittsburgh Steel Co., Monnessen, Pa.

Canadian Electrical Association, annual convention, to be held June 19-21, at St. Andrews-by-the-Sea, N. B. H. M. Lyster, secretary, Power Building, Montreal, Que.

Master Boiler Makers Association, at Atlanta, Ga., May 21-24. H. D. Vought, secretary, 26 Cortlandt St., New York City.

National Association of Power Engineers, 47th annual convention, Chattanooga, Tenn., Sept. 9-13. Fred Raven, secretary, 417 South Dearborn St., Chicago, Ill.

National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York City, Dec. 2-7. Charles F. Roth, manager, Grand Central Palace, New York City.

World Engineering Conference, Tokyo, Japan, October, 1929. All correspondence should be addressed to the Secretary, World Engineering Conference, Nikon, Kogyo Club, Morunouchi, Tokyo.

consumed by electric public utilities at the rate of 3.2 lb. per kw.-hr. in 1928, the increase in fuel consumption would have been about 38,000,000 tons, representing about $150,000,000."

It is to be added that if the 3.2 rate had obtained from 1919 through to the present day, the additional cost of fuel would have been of the order of $700,000,000. In other words, increased efficiency has cut this sum from the public expense.

Of the 60 per cent proportion of the total output generated by fuel last year, coal furnished 88 per cent, gas 7 per cent, oil 4 per cent and wood less than 1 per cent.

Personals

C. M. Taylor has been appointed sales manager of the Lincoln Electric Company, Cleveland, Ohio.

Paul D. Close has been appointed by the A.S.H.&V.E. to the newly created position of technical secretary of the society for the year 1929.

H. A. Baker, of Schenectady, N. Y., has been appointed as service manager of the International General Electric Company, with headquarters in New York City. Mr. Baker succeeds C. F. Neave, who has been named manager of the newly organized refrigeration department of the company.

Arthur W. Thompson has resigned as president of the United Gas Improvement Company, Philadelphia, Pa. His resignation comes as the result of ill health.

H. H. Wood, formerly chief engineer of the Laclede Steel Company of St. Louis, has joined the Industrial Department of The Timken Roller Bearing Company, Canton, Ohio.

Charles T. Main, past-president of the A.S.M.E., has been elected president of the American Institute of Consulting Engineers.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard	New York	$2.35@$2.40
Kanawha	Columbus	1.25@1.60
Smokeless	Cincinnati	2.15@ 2.25
Smokeless	Chicago	2.25
S. E. Kentucky	Chicago	1.35@ 1.60
Steam	Pittsburgh	1.55@ 1.75
Gas Slack	Pittsburgh	.90@ 1.10
Big Seam	Birmingham	1.25@ 1.50
Anthracite (Gross Tons)		
Buckwheat	New York	$2.75@$3.00
Barley	New York	1.00@ 1.50

FUEL OIL

New York—Feb. 28, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4⅜c. per gal.; 36@40 deg., furnace, tank-car lots, 6½c. per gal.

St. Louis—Feb. 21, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.50 per bbl. or 42 gal.; 26@28 deg., $1.55 per bbl.; 28@30 deg., $1.60 per bbl.; 30@32 deg., $1.65 per bbl.; 32@36 deg., gas oil, 5c. per gal.; 38@40 deg., distillate, 6¼c.

Pittsburgh—Feb. 18, f.o.b. local refinery, 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., 5½c. per gal.

Philadelphia—Feb. 18, 13@19 deg., $0.95@$1.02 per bbl. or 42 gal.; 22 deg. plus, $1.47@$1.53 per bbl.; 26@30 deg., $2.00@$2.06 per bbl.

Cincinnati—Feb. 25, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5½c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—Feb. 23, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 70c. per bbl.; 26@30 deg., 90c. per bbl.; 30@32 deg., $1.20 per bbl.

Boston—Feb. 25, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.5c. per gal.; 28@32 deg., 5.6c. per gal.

Dallas—Feb. 23, f.o.b. local refinery, 26@30 deg., $1.25 per bbl. or 42 gallons.

With the Society Sections

A. I. E. E., Regional Meeting, at Cincinnati, Ohio, Mar. 20-23, at the Hotel Gibson. Technical program and elaborate entertainment plans.

A. S. M. E., Knoxville Regional Meeting, Mar. 21-23, 1929. Technical program and trips to points of interest.

A. S. M. E., Philadelphia Section. Meeting Mar. 26. Subjects: "Resume of High Steam Pressures as Used in Industrial Plants," P. W. Swain. "Twelve-hundred Pound Holland Station of the Pennsylvania and New Jersey Power System," by E. M. Gilbert, W. S. Barstow Management Association, Reading, Pa.

American Water Works Association, Montana Section. Annual convention, to be held April 4 and 5 at Great Falls, Mont.

American Water Works Association, Florida Section. Meeting, April 10, at Jacksonville, Fla. Subject to be announced later.

Engineers Club of St. Louis. Meeting, Mar. 13. Subject: "The Automatic Control of Combustion in Boiler Furnaces," by Mellville Stein, Leeds & Northrup Co., Philadelphia, Pa.

Providence Engineering Society. Meeting Mar. 5. Subject: "The Narragansett Electric Company's System," by J. W. Young, electrical engineer of the Narragansett Company.

Second Annual Indiana Fuel Conference, at Purdue University, Lafayette, Ind., April 4-5.

Business Notes

The Linde Air Products Company, New York City, announces the opening of a new oxygen producing plant at 1241 North McLean Boulevard, Memphis, Tenn.

The Reiter Company, manufacturer of water softening and purification equipment, of Elgin, Ill., announces a change in its corporate name, as of Jan. 15, to the Elgin Water Softener Corporation. The management and officers will remain the same.

The Foote Bros. Gear & Machine Company announces the establishment of a New York branch office which will be in direct charge of E. A. Phillips. This office will be in the Woolworth Building.

The International Combustion Engineering Corporation announces that its subsidiary, the F. J. Lewis Manufacturing Company, will henceforth be known as the International Combustion Tar & Chemical Corporation, with general offices at 200 Madison Avenue, New York City.

The Consolidated Ashcroft Hancock Company, Inc., which has recently merged with the American

Schaeffer & Budenberg Corporation, has opened a central sales office at 100 E. 42nd St., New York City.

THE BROWN INSTRUMENT COMPANY, of Philadelphia, has secured larger quarters for its New York Office at 117 Liberty St., that city.

THE GENERAL REFRACTORIES COMPANY, of Philadelphia, has recently opened an office at 742 Russ Building, San Francisco. This office is in charge of W. E. Dornbach.

TRADE CATALOGS

DUTCH-OVEN FURNACE—The United States Iron Works, of Seattle and Portland, has issued a four-page leaflet on the Balden Dutch Oven furnace. It contains illustrations of various constructions as adapted to different conditions.

ELECTRICAL TUBING — The introduction of electrical metallic tubing by the Electrical Division of Steel and Tubes, Incorporated, Cleveland, Ohio, is made through an illustrated eight-page booklet.

CENTRIFUGAL PUMPS—The Lawrence Pump & Engine Company, of Lawrence, Mass., has included Bulletins D-20, D-21, D-25, D-28, and D-30 in a loose-leaf binding under the collective title of Lawrence "Vortex" Centrifugal Pumps. The total of pages is 16, and there are many valuable tables and interesting illustrations.

ELECTRICAL MACHINERY — The history of the Crocker-Wheeler Company, Ampere, N. J., has been reviewed in a 24-page booklet containing many views of the plant and some of its products, by Larkin & Jennys, of New York City. The publication covers the technical, commercial and financial phases of development in this company.

BLOW GUNS AND FLOW INDICATORS—Schutte & Koerting Company, Philadelphia, Pa., has recently published two leaflets, Bulletins 4-T and 6-F respectively, the first on blow guns and forge blowers and the second on flow indicators for use in pipe lines. Both are illustrated.

AIR COMPRESSORS—Bulletin No. 144, issued by the Pennsylvania Pump & Compressor Company, Easton, Pa., contains 16 pages of illustrated and printed matter concerning the company's duplex air compressors.

ROTARY BLOWERS—A four-page leaflet describing the Victor Rotary Positive Blowers, numbered 121, is put out by the Connersville Blower Company, Connersville, Ind. Besides illustrations, it lists some of the processes to which blowers have been successfully applied and gives tables of machine capacities.

TACHOMETER — The O. Zernickow Company, New York City, has issued an eight-page leaflet describing its line of hand and mounted tachometers. A general description, illustrations, and a table of specifications are included.

New Plant Construction

COMPILED BY THE MCGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

California—Pacific Gas & Electric Co., 245 Market St., San Francisco, has been granted permit by the State Dept. of Water Rights, Sacramento, to appropriate 125 cu. second ft. and 85,000 acre ft. of water from the north fork of Mokelumne river in Amador and Calveras counties for power purposes, estimated to cost approximately $25,000,000; also 9,412 acre ft. of water from Deer Creek in Alpine county to develop 14,170 hp., and 8,600 acre ft. from Deer Creek to develop 16,600 hp.

Calif., Downey—Los Angeles County is having plans prepared for the construction of a hospital building, including steam heating system. Estimated cost $600,000. K. W. Muck, Hall of Records, is architect.

Calif., La Jolla—Los Angeles Syndicate, awarded contract for a 4 story hotel to T. A. Westgate Co., 914 Merritt Bldg., Los Angeles. Estimated cost $600,000. Steam heating system, elevators, etc., will be installed.

Calif., Los Angeles—Kaspare Cohn Hospital, 3942 Whittier Blvd., will soon award contract for an 8 story hospital, including boiler room at Fountain Ave. Estimated cost $1,000,000. C. Beelman, 1019 Union Bank Bldg., is architect.

Calif., Los Angeles—M. Pixler, awarded contract for a 13 story apartment building at Wilshire Blvd. and La Brece Ave., to Investments Inc., 1308 Financial Center Bldg. Estimated cost $1,000,000.

Calif., Oakland—Nugget Bar Placers Inc. has been granted permit by State Dept. of Water Rights, Sacramento, for appropriation of 62.5 cu. second ft. of water from Swift Creek in Trinity county for mining and power purposes. Estimated cost $25,000.

Calif., Sacramento — Consumers Ice & Cold Storage Co., 9th and C Sts., awarded contract for the construction of an ice plant to include 180 ton freezing tank and installation of machinery and equipment, also cold storage plant at 9th and D Sts., to W. W. Williamson, 345 Market St., San Francisco. Estimated cost $225,000 and $61,500 respectively.

Calif., San Diego—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until Mar. 27 for the construction of two pump houses, etc., at Naval Operating Base, Naval Air Station, here.

Calif., Woodland—Rio Oso Fruit Co. has been granted permit for appropriation of 11.5 cu. second ft. of water from Bear River for power and irrigation. Estimated cost $31,000.

Conn., Bridgeport — United Illuminating Co., F. Cutts, Mgr., 1115 Broad St., is having plans prepared for addition to power generating station, also power service building at East Main St. Estimated cost $350,000 and $175,000 respectively. Westcott & Mapes, 139 Orange St., New Haven, are engineers.

D. C., Washington — Potomac Electric Co., 231 14th St. N. W., will soon award contract for addition to sub-station on Sherman St. N. W. Estimated cost $60,000.

Idaho, Boise — Bureau of Reclamation, Denver, Colo., will receive bids until June 15 for the construction of a hydro-electric power dam, on Deadwood River to impound 160,000 acre ft. of water in connection with Boise irrigation project. Estimated cost approximately $1,200,000.

Ill., Chicago — La Salle Ave. Baptist Church, 1219-23 La Salle St., awarded contract for masonry, etc., for a 17 story apartment building at 1211-1217 North La Salle St. Estimated cost $1,000,000. Steam heating system, elevators, etc., will be installed.

Ill., Chicago — Syndicate, c/o M. Flicht, 105 West Adams St., will soon award contract for the construction of first unit of building development at Milwaukee Ave. and Belle Plaine St. Estimated total cost $4,000,000.

Ill., Chicago — Syndicate, c/o K. M. Vitzhum & Co., 307 North Michigan Ave., Archts., awarded general contract for the construction of a 47 story bank and office building at La Salle and Madison Sts., to John Griffits & Sons Co., 228 North La Salle St. Estimated cost $8,000,000.

Ill., East St. Louis—East Side Levee & Sanitary Dist., J. D. Johns, Pres., 213 Metropolitan Bldg., received lowest bid for the construction of two pumping stations, one 43 x 75 ft. with four 54 in. screw pumps and the other 28 x 30 ft. with two 36 in. screw pumps from H. H. Hall Construction Co., Murphy Bldg. $402,000 on oil burning engines and $377,800 on motor driven type.

La., New Orleans—Commercial Hotels Inc., awarded contract for a 17 story hotel on Dryades St., to R. P. Farnsworth & Co., Maritime Bldg. Estimated cost $1,850,000. Steam heating, ventilation and refrigeration systems, boiler, pumps, elevators, etc., will be installed.

La., New Orleans—Favrot & Livaudais, Hibernia Bank Bldg., Archts., will receive bids until Mar. 26 for the construction of a boiler plant and equipment on Gravier St. for Charity Hospital, Tulane Ave. Estimated cost $110,000.

Md., Baltimore—J. Gutman & Co., Park Ave. and Lexington St., is having plans prepared for an 8 story department store including steam heating system, etc., at 211-213 West Lexington St. Estimated cost $500,000. Smith & May, Calvert Bldg., are architects.

Mass., Boston — Bureau of Yards & Docks, Navy Dept., Washington, D. C., plans the construction of a power plant and distribution system, etc., here. Estimated cost $75,000.

Mass., Weymouth—Edison Electric Illuminating Co., 39 Boylston St., Boston, plans the construction of a transmitting station near Edison power plant here. Private plans.

Mich., Detroit—Salvation Army, 564 Michigan Ave., plans the construction of a 3 or 4 story hospital, children's home, etc., including steam heating system at Fort St. and West Grand Blvd. Estimated cost $1,025,000. Architect not selected.

Mich., Detroit — Summerfield & Hecht, Michigan Ave., is having plans prepared for a 10 story mercantile buliding, including steam heating system, boilers, elevators, etc. C. N. Agree, 1140 Book Tower Bldg., is architect.

Minn., St. Paul — Merchants National Bank & First National Bank, Consolidated, J. A. Oace, Merchants National Bank Bldg., plans the construction of a 16 story office building, including steam heating system, etc., at Fourth St. between Cedar and

Minnesota Sts. Graham, Anderson, Probst & White, 80 East Jackson St., Chicago, Ill., are architects.

Miss., Hattiesburg—State Teachers College c/o W. C. Trotter, secy. Mississippi State Bldg. Comn., will receive bids until Apr. 4, for the construction of an administration building, dormitory, power plant, etc., here. Estimated cost $160,000. V. B. Smith, Bank of Gulfport Bldg., Gulfport, is architect.

Missouri—Corp., c/o C. T. Brotherton, is having preliminary plans prepared for the construction of electric light plants, also distribution lines at Meta, St. Thomas, Henley, Marys Home, Eugene and Vienna. Estimated total cost $92,000.

Mo., Billings—City plans an election soon to vote $35,000 bonds for waterworks improvements, including booster pump, tank on tower, etc. Russell & Axon, McDaniel Bldg., Springfield, are engineers.

Mo., Harrisonville — City Council plans the construction of a municipal electric light plant and power house. Estimated cost $65,000. Rollins & Co., Railway Exchange Bldg., Kansas City, are engineers.

Mo., St. Louis—Laclede Power & Light Co., 1017 Olive St., awarded contract for the construction of a power sub-station at Folsom and Thurman Aves., to Woermann Construction Co., 1441 Syndicate Trust Bldg.

N. J., Caldwell—Bd. of Education, Boro Hall, plans an election Mar. 4 to vote $450,000 bonds for addition to high school, including central heating plant. Guilbert & Betelle, 20 Branford Pl., Newark, are architects.

N. Y., Colonie (West Albany P. O.)—Bd. of Supervisors, Court House, Albany, will receive bids until Mar. 12 for remodeling of power house, etc., in connection with Albany County's poor house and hospital development here. Estimated cost $2,000,000.

N. Y., Taghkanic (mail Caryville)—New York Power & Light Co., subsidiary of Mohawk-Hudson Power Corp., 126 State St., Albany, has made application to Public Commission for permit to construct electric light plant here.

N. Y., New York — Mack Kanner and J. S. Becker, Contractors, taking bids on mechanical equipment incl. steam generating unit for 36 story, hotel, 8th Ave. & 34th to 35th Sts., for New York Hotel Corp., c/o Jones & Neuberger, 115 Bway.

O., Akron—Ohio Bell Telephone Co., c/o A. W. Bailey, 750 Huron Rd., Cleveland, will soon award contract for a 6 story telephone building, including steam heating system, etc., at Bowery and Quaker Sts. Estimated cost $700,000. Mills, Rhines, Bellman & Nordoff, Ohio Bldg., Toledo, are architects.

O., Toledo—Manhattan Building Co., A. Hahn, awarded contract for a 9 story apartment building, including steam heating, ventilation and refrigeration systems, boilers, elevators, etc., at Madison Ave. and 16th St. Estimated cost $2,000,000.

Okla., Blair—City, W. D. Snow, Clk., will soon award contract for the construction of a new waterworks system, including deep well pump and motor. Estimated cost $31,000. Milliken & Whitenech, Oklahoma City, are engineers.

Okla., Maud—E. Hill, Tradesmen's National Bank Bldg., Oklahoma City, will build an ice plant here by day labor. Estimated cost $40,000.

Okla., Seiling — J. Welborn, Geary, is having preliminary plans prepared for a 15 ton ice plant. Estimated cost $25,000. Private plans.

Pa., Media — Bd. of Delaware County Commissioners is having plans prepared for the construction of a central power plant. Estimated cost $75,000 including equipment. S. A. Jellett Co., 1200 Locust St., is engineer.

Tex., Abilene—H. O. Wooten is having plans prepared for the construction of a 19 story hotel and theatre building, including steam heating, ventilation, refrigeration and cooling systems, boilers, pumps, elevators, etc., at North 3rd and Cypress Sts. Estimated cost $750,000. D. S. Castle Co., 701-4 Alexander Bldg., is architect.

Tex., San Antonio—Mission Ice Co., H. G. Terry, 226 Rivas St., awarded contract for a 30 ton ice plant at Culebra Rd. and Zaramora St., to E. A. Huebner, Moore Bldg. Estimated cost $45,000.

B. C., Ruskin—British Columbia Electric Railway Co., 425 Carroll St., Vancouver, awarded contract for the construction of a hydro-electric power dam, 183 ft. high and 325 ft. long on Stave river in connection with Ruskin power development to Armstrong, Morrison & Stuart Cameron Ltd., 543 Granville St., Vancouver, $882,987. Total cost $7,250,000. Cement to be supplied by owners at a cost of $300,000.

B. C., Vancouver — Britisn Columbia Electric Railway Co., 425 Carroll St., awarded contract for the construction of a power distribution plant to Parfitt Bros. Estimated cost $40,000.

N. B., Moncton — Moncton Cold & General Storage Ltd., c/o Sargent-Howard-Latourelle Ltd., 6 Craig St. W., Montreal, Que., plans the construction of a cold storage plant here. Estimated cost $200,000. W. H. Wardwell, 1463 Union St., Montreal, Que., is engineer.

Ont., Belleville — Local Syndicate plans the construction of an artificial ice rink. Estimated cost $75,000. A. Thomson & Johnson, 224 Front St., are architects.

Ont., London—Hotel London, R. H. Lussier, Mgr., will soon receive bids for the construction of an 8 story addition to hotel including steam heating system, etc., on Dundas St. Estimated cost $500,000. J. M. Moore & Co., 489 Richmond St., are architects.

Ont., Toronto — Syndicate, c/o Kirk Hyslop, 10 Sparkhall Ave., is having plans prepared for a 20 story office building, including steam heating system, elevators, etc., at Bay and Albert Sts. Estimated cost $1,000,000.

Equipment Wanted

Boilers, Stokers, etc.—City Council, D. W. Campbell, Recorder, Luverne, Minn., will receive bids until Mar. 14 for two water tube boilers, 160 lb. pressure, two stokers and accessory equipment.

Boilers, Stokers, Generator and Condenser, etc. — Public Utilities Commission, 817 Franklin St., Manitowoc, Wis., will receive bids until Mar. 14, for furnishing and installing two 800 hp. boilers, 400 lb. pressure with stokers or pulverized fuel firing equipment, also 5,000 kw. turbo-generator with condenser and auxiliary equipment.

Electrical Equipment — General Steel Wares Ltd., J. M. Moore, 489 Richmond St., London, Ont., prices on complete electrical equipment for the manufacture of enamelware for oven house. Estimated cost $50,000.

Generator and Condenser—City of Hillsdale, Mich., plans to purchase a 1,500 kw., 60 cycle turbo generator and jet condenser and equipmet, for proposed waterworks improvements. Estimated cost $40,000.

Generator Set — Library Dept., Boston, Mass., will receive bids until Mar. 20 for a motor generator set for library at Copley Sq.

Pump—City of Beverly Hills, Calif., is receiving bids for furnishing and installing a deep well turbine pump for proposed waterworks improvements.

Pump—City of Raymondville, Tex., is receiving bids for a 350 g.p.m. electric turbine pump.

Pumping Equipment — City of Forest, Miss., will receive bids until Mar. 12 for pumping equipment, etc., for proposed waterworks system.

Pumping Equipment — City of Weimar, Tex., will soon receive bids for pumping equipment, etc., for proposed waterworks and distribution systems. Estimated cost $50,000.

Pumps—Bd. of Trustees, De Kalb Sanitary Dist., De Kalb, Ill., will receive bids until Mar. 20 for pumps, etc., for proposed sewage treatment work.

Pumps, etc.—City of Lafayette, La., J. G. St. Julian, Mayor, will receive bids until Mar. 21 for pumps, etc., for proposed sewage treatment work.

Pumps, etc.—City plans to purchase a 500 g.p.m. booster pump and 500 g.p.m. fire pump for proposed waterworks improvements. Estimated cost $166,500.

Pumps, etc.—City of Wheatland, Calif., plans to purchase pumps, etc., for proposed sewage treatment plant. Estimated cost $25,000.

Turbine and Generator Units — R. C. Lawellin, Clk., Stillwater, Okla., will receive bids until Mar. 12 for a 1,875 kw. steam turbine unit and generator unit together with surface condenser for municipal light plant. Estimated cost $25,000.

Turbine, Condensing Unit, etc.—City of Owatonna, Minn., will receive bids until Apr. 8 for one turbine for generating electric power, also condensing unit for municipal power plant. Estimated cost $50,000.

Industrial Projects

Calif., Long Beach—ASSEMBLY PLANT and POWER HOUSE — Ford Motor Car Co., 1004 Marquette Bldg., Detroit, Mich., will soon award contract for the construction of a 315 x 920 ft. assembly plant, including 83 x 101 ft. power house here. A. Kahn, Inc., 1000 Marquette Ave., Detroit, Mich., is architect.

Calif., Oakland — CAN FACTORY and STEAM PLANT—Continental Can Co., 155 Montgomery St., San Francisco, awarded contract for a 3 story can factory, including steam plant, etc., at Russett St. and 54th Ave. to Scofield-Twaits Co., Hunter-Dulin Bldg., San Francisco. Estimated cost $600,000.

Conn., Hartford — GOLD LEAF FACTORY and BOILER HOUSE—M. Swift & Sons, 100 Love Lane, awarded contract for a 45 x 175, 25 x 40 and 20 x 50 ft. factory, including boiler house and coal pocket units, to A. F. Peaslee, 15 Lewis St. Estimated cost $100,000.

Md., Baltimore — AEROPLANE FACTORY — Berliner-Joyce Aircraft Corp., Hearst Tower, will soon award contract for a 1 story, 140 x 240 ft. aeroplane factory. Estimated cost $250,000. Kubitz & Koenig, Emerson Tower, are engineers.

Mich., Dearborn—AUTOMOBILE FACTORY ADDITION — Ford Motor Corp. awarded contract for a 1 story, 60 x 320 ft. addition to automobile factory on Coolidge Highway to J. W. Butler Construction Co., Penobscot Bldg., Detroit. Electric motors, etc., will be installed.

Mich., Detroit — ADDING MACHINE FACTORY — Burroughs Adding Machine Co., Cass and Burroughs Aves., awarded contract for a 1 story, 60 x 180 ft. factory to Corrick Bros., 507 Owen Bldg. Estimated cost $50,000.

Mich., Detroit — STAMPING PLANT — Hupp Motor Car Corp., 3641 East Milwaukee Ave., awarded contract for a 1 story, 40 x 500 ft. stamping plant to Everett Winters Co., 1651 East Grand Blvd. Estimated cost $150,000. Electric motors and presses for metal stamping department will be installed.

Mich., Detroit—LEAD PIPE FACTORY —Detroit Lead Pipe Works, 600 West Larned St., plans the construction of a 1 story lead pipe factory on Livernois Ave. Estimated cost $75,000. Electric motors and equipment will be required.

Mich., Lansing—MOTOR PLANT ADDITION—Olds Motor Works, plans the construction of a 2 and 4 story, 85 x 315 ft. addition to 2 and 4 story, 85 x 315 ft. addition to plant at Walnut and Olds Ave. Estimated cost $170,000. Verner, Wilhelm & Molby, 750 Book Bldg., Detroit, are architects.

Mich., Detroit — AIRCRAFT ENGINEERING BUILDING and POWER PLANT — Packard Motor Car Co., East Grand Blvd., awarded contract for a 2 story, 65 x 125 ft. and 3 story, 63 x 187 ft., including detached power plant on East Grand Blvd. to Everett Winters Co., 1651 East Grand Blvd. Estimated cost $250,000. Equipment for the manufacture of Diesel motors will be installed.

Mich., Northville — FURNITURE FACTORY ADDITION—Detroit House of Correction, E. Dennison, Supt., plans the construction of a 2 story addition to furniture factory in connection with prison institution. Estimated cost $100,000. A. Kahn, 1000 Marquette Bldg., Detroit, is architect. Electric motors, etc., will be installed.

O., Cleveland — TELEPHONE SUPPLY FACTORY — National Telephone Supply Co., F. P. Auxer, Pres., 5100 Superior Ave., is receiving bids for a 2 story addition to factory. Estimated cost $60,000. G. S. Rider Co., Century Bldg., is architect.

Wash., Seattle — WOODWORKING PLANT—Fisher Body Corp., E. F. Fisher, General Motors Bldg., Detroit, Mich., plans the construction of a woodworking plant here. Estimated cost $1,500,000.

Ont., Port Hope—CONVEYOR PLANT —Matthews Conveyor Co. will soon receive bids for a 1 and 2 story, 40 x 60 and 60 x 80 ft. conveyor plant on John St. Estimated cost $50,000. Private plans.

Ont., Toronto — BATTERY FACTORY ADDITION—Prest-O-Lite, 805 Davenport Rd., will soon receive bids for a 3 story, 80 x 400 ft. addition to battery factory at Geary Ave. and Dufferin St. Estimated cost $150,000. Private plans.